STUDIES OF EMOTION RECOGNITION FROM MULTIPLE COMMUNICATION CHANNELS

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Studies of emotion recognition from multiple communication channels

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Declarations

I, Sophia J. Durrani, hereby certify that this thesis, which is approximately 60,000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

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Emotions shape our lives, yet we understand very little about them. I hope that with this thesis I can convey some of the fascination and challenges that have drawn me to the field of emotion research.

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For my parents,

Who introduced me to the

joys and fascinations of

man's ultimate aim –

the pursuit of knowledge.

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ABSTRACT

Crucial to human interaction and development, emotions have long fascinated psychologists. Current thinking suggests that specific emotions, regardless of the channel in which they are communicated, are processed by separable neural mechanisms. Yet much research has focused only on the interpretation of facial expressions of emotion. The present research addressed this oversight by exploring recognition of emotion from facial, vocal, and gestural tasks. Happiness and disgust were best conveyed by the face, yet other emotions were equally well communicated by voices and gestures. A novel method for exploring emotion perception, by contrasting errors, is proposed.

Studies often fail to consider whether the status of the perceiver affects emotion recognition abilities. Experiments presented here revealed an impact of mood, sex, and age of participants. Dysphoric mood was associated with difficulty in interpreting disgust from vocal and gestural channels. To some extent, this supports the concept that neural regions are specialised for the perception of disgust. Older participants showed decreased emotion recognition accuracy but no specific pattern of recognition difficulty. Sex of participant and of actor affected emotion recognition from voices.

In order to examine neural mechanisms underlying emotion recognition, an exploration was undertaken using emotion tasks with Parkinson's patients. Patients showed no clear pattern of recognition impairment across channels of communication. In this study, the exclusion of surprise as a stimulus and response option in a facial emotion recognition task yielded results contrary to those achieved without this modification. Implications for this are discussed.

Finally, this thesis gives rise to three caveats for neuropsychological research. First, the impact of the observers' status, in terms of mood, age, and sex, should not be neglected. Second, exploring multiple channels of communication is important for understanding emotion perception. Third, task design should be appraised before conclusions regarding impairments in emotion perception are presumed.

1 INTRODUCTION

1.1 Introduction to emotion perception

Emotions are crucial to human interaction, and as a consequence, they have captivated researchers from a diverse range of disciplines. The development of new imaging techniques has given new impetus to the exploration of emotion perception, and research on the subject has exploded in recent years. Within the psychological framework, some studies have addressed overt recognition of emotion portrayed by human expressions, whilst others have examined the inter-relationships between emotions and the particular scenarios and contexts that they might evoke. Some have investigated physiological responses to emotion-eliciting stimuli including skin conductance and heart rate changes; in contrast, others have examined brain activation or attenuation patterns to emotional stimuli.

Processing emotions is fundamental for social communication, since interpreting emotional cues enables us to ascertain our counterparts' intentions and internal states, and guides appropriate responsive behaviour. When the ability to interpret such cues breaks down, social consequences can be extensive. This thesis is concerned with two distinct aspects that might influence the interpretation of emotional states. The first is the observer's status, which is often neglected in neuropsychological research. To address this, the impact of moods (Chapters 3-5), sex (Chapter 6), and age (Chapter 8) on emotion perception is explored. The second aspect involves the way in which emotions are communicated. Research specifically examining the recognition of emotions has generally been restricted to using components of facial expressions and, to a lesser extent, vocal expressions. The face is a widely used research tool since it is considered by many to be the most telling bearer of a person's emotional state. Despite this, in a genuine social situation when one person observes another displaying an emotion, several types of cues can determine the emotion that is expressed. These cues include body posture, gestures, speech content, prosody, eye gaze, and contextual signals, such as situation. Consequently, this thesis describes a series of novel studies that investigate recognition of emotion from multiple communication channels, including facial, vocal, and gestural expressions. The efficacy and potential diagnostic value of the tests of expression recognition employed are explored.

Following this, a clinical exploration of emotion processing in a population with limited expressive abilities due to neurological disease is presented in Chapter 9 and neural pathways involved in emotion perception are conjectured. The motivation for this research has been the drive for knowledge of neural processes associated with emotion perception. To provide insight into disorders associated with emotion processing dysfunction, it is important to further our understanding of the structure of emotion and its neural basis. This is the focus for part of this review.

This thesis presents a short account of theories of emotion, how emotions differ, and how they relate to experience. This is followed by a review of neuroscience studies that have provided evidence for a partial separation of the brain structures subserving different emotions. Limitations of neuropsychological research are highlighted and addressed within the studies described in this thesis.

1.2 Basic emotions – different approaches

1.2.1 Introduction to different theories of emotion

In the last one hundred and fifty years, theories of emotions have emerged in different areas of human knowledge, including biological, behavioural, and cognitive approaches to the study of emotion.

The James-Lange Theory (James, 1884; Lange, 1885) is one of the foremost biological approaches to emotion. The theory states that a stimulus triggers a reflexive physiological response and body movement (e.g. perspiration, heart rate elevation, facial expression). Emotions occur when the individual evaluates and interprets his/her own bodily changes.

Cannon (1927) challenged this stance by arguing that since humans can respond to an affective stimulus within a few milliseconds, whereas the viscera respond much slower than this, visceral changes are too slow and insensitive to be the source of emotional feeling. Artificial induction of physiological changes did not produce characteristic real emotions. As a consequence, Cannon concluded that emotion is a cognitive event, enhanced by bodily arousal, which occurs simultaneously to the experience of the emotion. Cannon provided the first substantial theory of brain mechanisms involved in emotion. He proposed that the thalamus is activated by the perception of an event and then it alerts the cortex and hypothalamus for action: the cortex is responsible for emotional feelings and behaviour, and the hypothalamus is responsible for arousing the body.

In support of this, disturbance to the hypothalamus causes impairments to the experience of emotions. For instance, Hess (1950) applied electrical stimulation to the hypothalamus region in cats; this aroused and alerted the cats. If stimulation was prolonged, the cats became aggressive.

Another classic theory of emotions is the Cognitive Appraisal Theory, proposed by Schachter and Singer (1962). This theory concurs with the James-Lange Theory that the experience of an emotion arises from the cognitive labelling of a physiological sensation. Nevertheless, the Cognitive Appraisal Theory suggests that this labelling is constrained by context. To test this notion, Schachter and Singer induced a state of arousal in individuals (using injections of adrenaline). The participants were not informed with regard to the effect of the injection. When placed in a pleasant social situation, the participants felt happy. Yet participants placed in a frustrating context felt and acted angrily. Thus, there appears to be a misattribution of 'feelings' in these cases. Despite these findings, replication of this result has proved difficult (Oatley & Jenkins, 1996).

Lazarus (1991) described emotional responses as the outcomes of internal and situational appraisal processes. The three possible emotional responses may be: biological urges to act, subjective affect, and physiological changes.

A somatic-marker hypothesis was presented by Damasio (1994), in which he argued that humans have ongoing awareness of their somatosensory system. For instance, when an emotion is experienced, the memory of this experience becomes associated with the concurrent bodily changes and state. Subsequently, when that emotion is re-experienced in perception or memory, the bodily state that marks this emotion is also re-experienced. This associated between emotion and bodily state is a 'somatic marker'. Somatic markers, in this sense, represent emotional learning. Damasio suggested that the neural mechanisms underlying emotion and those involved in reason partially overlap.

Another key emotional theory suggests that specific dimensions define emotions, in terms of their perception and experience. The idea that emotions may be dimensional has its original roots in a simple concept that emotions can be defined as varying along a positive or negative dimension (Tomkins, 1962; 1963). Models pioneered by Woodworth and Schlosberg (1954), and developed further by Russell (1980), indicate that emotions can be defined by the specific dimensions of pleasantness-unpleasanteness, attention-rejection, and sleep-tension. The differences between each emotion are determined by their positions in relation to these dimensions.

Phillips and colleagues (2003a) have proposed neural systems for underlying processes involved in emotion perception: a ventral system, including the amygdala and insula, would mediate the identification of emotionally salient cues. In response, an affective state and emotional behaviour would be produced. These behaviours and states would then be regulated, involving a dorsal system, including the hippocampus.

There are several more theories of emotion than those discussed and new theories are progressively being developed; yet those described are some of the primary theories regarding emotion, its structure, and neural bases.

1.2.2 Basic emotions

In order to study emotions and to understand their structure and inter-relationships, finite lists of 'basic' emotions have been proposed. The psychological view is that there is a small set of emotions from which all emotions stem (Ortony & Turner, 1990). A basic emotion, in this sense, would be irreducible. It would not overlap with any other emotion. Non-basic emotions would be blends of these emotions. Thus, the entire human repertoire of emotions could be explained in terms of basic emotions. Table 1.1 summarises key researchers and their proposals for basic emotions.

Table 1.1: A selective list of 'basic emotions'. Adapted from Ortony & Turner (1990).

Reference	Fundamental emotions	Reason for inclusion
Arnold (1960)	Anger, aversion, courage, dejection, desire, despair, fear, hate, hope, love, sadness.	Relation to action tendencies.
Ekman, Friesen, and Ellsworth (1982)	Anger, disgust, fear, joy, sadness, surprise.	Universal facial expressions.
Frijda (1986)	Desire, happiness, interest, surprise, wonder, sorrow.	Forms of action readiness.
Gray (1982)	Rage and terror, anxiety, joy.	Hardwired.
Izard (1971)	Anger, contempt, disgust, distress, fear, guilt, interest, joy, shame, surprise.	Hardwired.
James (1884)	Fear, grief, love, rage.	Bodily involvement.
McDougall (1926)	Anger, disgust, elation, fear, subjection, tender-emotion, wonder.	Relation to instinct.
MacLean (1990)	Desire, affection, fear, anger, sadness, ecstasy	Derived from activities in the limbic system
Mowrer (1960)	Pain, pleasure.	Unlearned emotional states.
Oatley and Johnson-Laird (1987)	Anger, disgust, anxiety, happiness, sadness.	Do not require prepositional content.
Panksepp (1982)	Expectancy, fear, rage, panic.	Hardwired.
Plutchik (1982)	Acceptance, anger, anticipation, disgust, joy, fear, sadness, surprise.	Relation to adaptive biological processes.
Tomkins (1984)	Anger, interest, contempt, disgust, distress, joy, fear, sadness.	Density of neural firing. Related to facial expressions.
Watson (1930)	Fear, love, rage.	Hardwired.
Weiner and Graham (1984)	Happiness, sadness.	Attribution independent.

Disparities between lists of basic emotions can largely be accounted for by different reasons for their inclusion. For instance, some researchers suggest that emotions exist for motivation, others emphasise their role in communication, while others consider that emotions play an important role in cognition. Some theorists propose that emotions must be affectively valenced (i.e. either positive or negative). Other proposals infer that basic emotions have specific neurophysiological and anatomical substrates, which would suggest that these emotions are universal to all human cultures and could appear in other animal species.

The diversity of language provides further complications in the search for a set of basic emotions. Consider anger and rage: the terms are relatively synonymous in western cultures and may refer to the same phenomenon, as could happiness, joy, and elation.

A convincing evolutionary explanation of basic emotions would account for their functions, their phylogeny, and why they exist at all. Darwin (1872) believed that each basic emotion should have a distinct expressive correlate that is demonstrated cross-culturally. His primary argument was that basic emotions must have some sort of universal status. The central tenet of his research was that these emotions have evolved for functional purposes, such as a role in social communication and the regulation of emotional experience. He was not the first researcher to propose the universality thesis, but he was among the first to link emotions with evolution. Darwin (1872) described approximately a dozen basic facial expressions of emotion that he believed were vestiges of once-useful physiological reactions. He enunciated three general principles that guided the evolution of expressions. The first is related to serviceable associated habits, such that certain states of mind become associated with a particular action in order to relieve or gratify that state, and force of habit leads one to perform this actions whenever that state is experienced. The second is connected with antithesis (when happy, the mouth turns upwards; when sad, the mouth turns downwards; when in a positive state an animal's ears may point upwards, when in a negative state, they may turn down). The final principle is that of direct action of the nervous system – senses are excited, bodily changes induced, and expressive effects result. Darwin's seminal work provided an important departure point for modern scientific emotion research.

Over a century later, Plutchik (1982) proposed an alternative list of basic emotions. Each emotion, he claimed, has a different form of expression in various species, but there are identifiable, common elements. Researchers, like Plutchik and Darwin, believe that basic emotions are hard-wired, i.e. they are part of our genetic and evolutionary composition.

Ekman and his colleagues (1971; 1969) collected facial expression data from preliterate cultures in Borneo and New Guinea that had very little contact with the outside world. The rationale behind this study was that if people living in these cultures demonstrated similar facial expressions to those of people in western cultures, and recognised them in others, then these facial expressions must have a universal quality, which may be genetic in origin, and are not necessarily socially learned.

The first task adopted forced-choice procedures, in which the participants were shown photographs of people displaying different facial expressions and the participants had to indicate which emotion (from a list) it was that they were expressing (Ekman et al., 1969). The second task involved telling the participants stories that would elicit emotions, such as 'You see a dead pig that has been lying there for some time'. The participants' task was to firstly, pick one face from three photographs that corresponded to the emotion that would be experienced; and secondly, to adopt a facial expression, which would be appropriate in that particular situation. Their facial expressions were presented to American students to identify. There was slight confusion between participants' displays of fear and surprise, but all the other expressions were recognised significantly better than at chance levels. This investigation led to the conclusion that there are six basic, universal emotions defined by distinctly different facial expressions: happiness, surprise, sadness, fear, anger, and disgust. Contempt has since been added to this list (Ekman, O'Sullivan, & Matsumoto, 1991), despite being contested to some extent.

Russell (1994) criticised Ekman's conclusions. He attacked the forced-choice procedure that Ekman initially adopted (Ekman & Friesen, 1971; Ekman et al., 1969). By using such a method, Russell argued that it is possible to over-estimate the participants' accuracy at recognising specific emotions, as forced-choice procedures restrict choices. Russell's critique is supported by work carried out with the same tribe that Ekman studied: Sorenson (1976) found that when the tribe members were presented with photographed facial expressions, and asked to label them freely, they demonstrated difficulties in recognising surprise and disgust faces.

Calder and his colleagues (1996) carried out a study that involved a series of facial expressions, which were blends of easily confused emotions from Ekman and Friesen's list of six emotions. Each target face contained proportions of two expressions (0:100, 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, 90:10, 100:0). They asked people to indicate which emotion each face depicted. There was not a gradual change in labelling from one emotion to the other that mirrored proportion shifts. Distinct perceptual shifts were observed, given that transition occurred from labelling the faces as one emotion to labelling it as the other at a specific point when discrimination was most sensitive. This was evidence for categorical perception of facial expressions. Etcoff and Magee (1992) achieved similar results, using line drawings as opposed to photographs. Furthermore, Ekman's basic emotions may also have distinct experiential, physiological, as well as expressive components (see Section 1.3).

If human facial expressions of emotion evolved solely due to communication needs, it would be expected that emotional displays would be most informative about expressers' intentions or emotional states when expressers are in the presence of others. Humans' evolutionary ancestors needed observers before they gained an advantage from emotional/communicative displays. Nevertheless, people do display emotions when in isolation, which suggests that emotion is not purely a communicative tool.

Some cultures show an inhibition of negative facial expressions when accompanied. Ekman (1972) presented film clips to 25 American and 25 Japanese men. These clips ranged from neutral, to unpleasant, to disturbing (canoe trip, baby delivery, circumcision). Participants initially viewed the clips alone. Then they were asked questions regarding their feelings towards the clips. In the final phase, the participants were shown the clips again, whilst the experimenter was seated facing them. They were asked to give commentary concerning how they felt during the film. During the entire study, their facial expressions were videotaped, unbeknown to them. In the first phase, the two groups showed very similar facial expressions. But in the final phase, the Japanese participants expressed more positive expressions, and inhibited any sign of distress or discomfort. Ekman postulated that though emotional expressions are universal cross-culturally, cultures determine display rules for these expressions in social contexts. By contrast, Fridlund (1994) replicated this video viewing experiment and suggested that the Japanese were more polite and looked more at the experimenter, rather than the clips. Thus, he implied that culturally determined display rules do not exist.

Neuropsychological research and imaging studies have provided evidence which indicates that there may be a degree of emotion-specific functional organisation for some emotions within the brain (see Section 1.5.2 for more information). In this thesis, recognition tests for the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) as proposed by Ekman and Friesen (1971), are employed, since this is one of the most popular lists of basic emotions used in neuropsychological research.

1.3 Basic emotions – descriptions

Components of emotions include cognitive processes, subjective feelings, physiological arousal (such as perspiration and heart rate changes), and behavioural reactions (such as facial expressions). There are a variety of definitions for each of Ekman and Friesen's (1971) basic emotions. To summarise from the Collins English Dictionary (Sinclair, 1994): happiness can be described as a state of well-being, pleasure and contentment. Surprise is defined as the state of being presented with something unexpectedly. Sadness is to be affected with grief and unhappiness. Fear is an intense awareness or anticipation of danger. Disgust is a marked aversion aroused by a highly distasteful observation. Anger is a strong emotional state induced by displeasure.

Following Ekman and Friesen's (1971) conclusions, the emphasis on the concept of universal emotional expressions obscures the wealth of variation within and between facial expressions; that is, everybody expresses individual differences in their facial emotions. Nevertheless, these basic emotions have universal units in the facial vocabulary (Ekman & Friesen, 1978; Heise, 1985). Happiness is revealed in upturned corners of the mouth (laughing also raises the cheeks which in turn may push the lower eyelids up). Surprise combines arched eyebrows with wide-open eyes and a dropped open mouth. Sadness is depicted by flattened and lowered brows, with the upper eyelids drooping and sloped, and the corners of the mouth are pulled downward. Fear shows in raised and flattened eyebrows, raised and tensed lower eyelids, along with side-stretched lips. Disgust involves raised lower eyelids, and the upper lip curled up so as to raise the nose (the upper nose may be crinkled). In anger, the brows pull down and inward, the eyes squint, and the lips either are pressed tight or squared into a snarl.

Research has also shown that emotional state can also be determined by physiological responses (Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). Levenson and colleagues (1990) asked participants to pose specific facial movements corresponding to expressions of Ekman and Friesen's six basic emotions. Participants were unaware of which expression they had adopted. Their heart rate, hand temperature, skin conductance, and forearm muscle tension were measured. A distinct pattern in the bodily responses was shown for each particular emotion. For example, heart rate increased with displays of sadness, anger, and fear. In an extension of this research, Levenson and his co-workers (1992) examined a group of males in West Sumatra, where public displays of negative emotion are strongly disapproved. The participants had to adopt facial movements, typical of specific facial expressions of emotion, while their physiological responses were recorded. Similar patterns to the American participants examined in the previous study were revealed. Therefore, it seems likely that each of Ekman and Friesen's basic emotions is characterised to some extent by a specific physiological response.

1.4 Production and recognition of basic emotional expressions

Central to the concept of universal basic emotions is the notion that emotional communication might be inherent or learned early in life.

1.4.1 Production

At birth it has been reported that infants show signs of interest, distress, disgust, and contentment (Shaffer, 1999). In contrast, Izard and colleagues (1995) reported that basic emotions (defined by Ekman and Friesen, 1971), except disgust, emerge between 2.5 months and 7 months of age. This could be a sign of maturational mechanisms, or the consequence of an element of social learning involved in emotion production.

Imitation and manipulation of facial gestures are observed in human neonates (Meltzoff & Moore, 1977, 1983) and to an extent in non-human primate neonates (Visalberghi & Ferrari, 2004). This also suggests that learning to differentiate among facial expressions may begin directly from birth.

Children who are born deaf and blind display similar emotional expressions to normal children (Goodenough, 1932). This substantially bolsters the idea that basic emotions have some innate quality. In accordance, Eibl-Eibesfeldt (1973) filmed five children who were born deaf and blind, and one other child who became deaf and blind at the age of 1 year. The children also had a range of birth defects and varied in intelligence levels. Close examination of the videos revealed that these children expressed crying, affection, surprise, frowning, frustration, pouting, conflict, and more, in a manner similar to expressions shown by normal children. Thus, children who are sensorily restricted and have reduced mental capacity show the same basic repertoire of spontaneous facial expressions as normal children, yet social learning is virtually impossible in their cases.

In contrast to this, Rinn (1984a) reported that congenitally blind participants were less proficient at posing basic emotional expressions than sighted control participants. This could reflect the functioning of two systems responsible for the production of facial expressions: a subcortical system, which controls *spontaneous* facial expression and a cortical system, which controls *volitional* facial movement (Rinn, 1984b). Therefore, since the ability to produce spontaneous facial expressions seems to follow a fixed developmental sequence resistant to developmental disruptions, as demonstrated by Eibl-Eibesfeldt's work, this bolsters the idea that there are innate capacities for expression.

From a phylogenetic point of view, it would be expected that there should be evidence of basic emotions in other species. In support of this, there is a close similarity between emotional facial expressions displayed by non-human primates and humans, fear, anger, and smiling, in particular (Schmidt & Cohn, 2001). Chevalier-Skolnikoff (1973) argued that some human expressions, such as those for anger, sadness, and affection, seem to be homologous and related through evolution to non-human primate expressions. There is further evidence for functional and emotional vocal communication systems in non-human primates (Gouzoules, Gouzoules, & Marler, 1984; Seyfarth, Cheney, & Marler, 1980). A bulk of literature discusses emotional displays, both vocal and visual, in non-human primates, but for this brief introduction, only key papers have been cited. Generally, research corroborates the idea that production of facial expressions is innate or has some phylogenetically-programmed maturational quality.

1.4.2 Recognition

If expression of emotions is genetic, it is plausible that reception might be learned. Nevertheless, substantial evidence for an innate recognition mechanism was provided by Sackett (1966). Eight captive monkeys, given no visual access to any other monkeys, showed signs of disturbance and vocalization when they were shown threatening pictures of monkeys. This behaviour consisted of fear, withdrawal, rocking, and huddling. The animals displayed exploratory and play behaviours towards the pictures when no direct threat was presented. Monkeys learned to avoid threatening faces during an operant reinforcing task. This indicates that animals may have some sort of innate fear response.

Research exploring emotion recognition has also focused on human infants. Using a visual habituation task, Field and colleagues (1982) reported that infants with an average age of 36 hours, discriminated between happy, sad, and surprised facial expressions. Furthermore, a one year-old infant will play with an unfamiliar toy if a stranger nearby is smiling; however, they will avoid the toy if the stranger looks fearful (Klinnert, Emde, Butterfield, & Campos, 1986). This provides support for early perception of emotion in the face. By 4 or 5 years of age, most children can accurately label emotions conveyed in various nonverbal channels, including the face. Caron and his colleagues (1988) established that dynamic expressions of anger and happiness are discriminated at 7 months of age, and vocal expressions are discriminated earlier than facial displays. Thus, vocal expressions may communicate more information to an infant than facial expressions. This research, combined with Sackett's study, supports the idea of an innate emotional recognition mechanism, perhaps specialising in fear processing, that matures with age.

1.4.3 Summary

Though there is a dearth of research concentrating on the issue of innate recognition and production of emotions, prime research suggests that there is an innate mechanism responsible for producing and recognising facial and vocal expressions of basic emotions, and this may be maturational in nature.

1.5 Emotion and related brain structures

Given that emotions seem to be recognised and expressed innately, this has led researchers to question what neural processes might be involved in these abilities.

The current neuropsychological view of functioning is that there are specific pathways within the brain dedicated to particular functions, such as motor control. The case of Phineas Gage, who suffered a major personality change following an accident, in which an iron bar became lodged through his cheek and into his frontal lobes, demonstrated that there are regions of the brain associated with social functioning. Despite no memory, language, or motor difficulties, Gage exhibited socially inappropriate behaviours and had difficulties with reasoning and judgement tasks (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994; McMillan, 1987).

Since basic emotions have distinct expressive, physiological, and experiential components, it has been proposed that they may also have discrete neural components too. This has led to an explosion in investigations for neural bases of social functioning, particularly of the perception of emotions. Understanding the roles played by particular brain structures and pathways in social functioning can be gained from animal research, human lesion studies, and imaging techniques. Fundamental to neuropsychological principles is the concept that to comprehend how a system works, we should observe what happens when it goes wrong, such as exploring perception abilities in populations with selective damage to the brain. Such clinical groups might show atypical patterns of processing as a result of deterioration or impairment to brain functioning. Behavioural correlates of particular brain regions in healthy people could be identified in this way. Furthermore, the recent emergence of imaging techniques, such as Functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET), has provided a means for investigating brain functions in healthy individuals. Combined, these research techniques have imparted much information regarding the neural nature of social communication.

1.5.1 Dissociable identity and expression recognition systems

Experimental and neuropsychological studies support the existence of two dissociable systems for recognising facial identity and for recognising facial expressions. This is central to Bruce and Young's (1986) cognitive model of face processing (Figure 1.1).

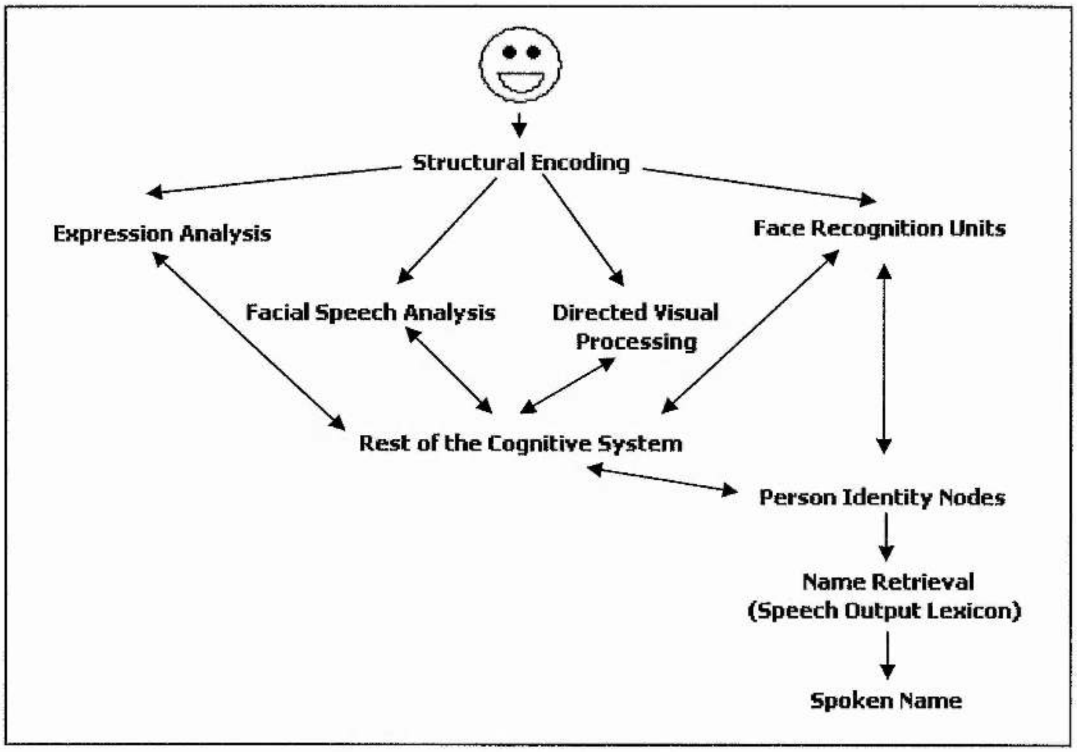


Figure 1.1: A model for face processing, adapted from Bruce & Young (1986).

Associative prosopagnosia is a condition whereby people have lost the ability to recognise familiar people by their faces. Prosopagnosics may rely on cues from voices, gait, and so on, to recognise that person. This condition does not result from a visual deficit; prosopagnosics do not have difficulties in describing facial features of that person or facial expressions of emotion (Etcoff, 1984; Tranel, Damasio, & Damasio, 1988). There are also conditions in which recognition of facial identity is intact, but recognition of some facial expressions is impaired – these cases are discussed in more detail in Section 1.5.2. Young and colleagues (1986) provided behavioural support for the dissociation between identity and expression processing. Participants were given an identity-matching task, in which they were asked to decide whether simultaneously presented photos were of the same or different people. Participants were faster to decide if they were familiar faces, regardless of facial expressions. In an expression-matching task, there were no differences in response times for familiar and unfamiliar faces – thus, judgements of expression were not influenced by identity or vice versa.

This work is supported by neurophysiological investigations. Hasselmo and colleagues (1989) explored single cell recordings of forty-five neurons in the temporal visual cortex of macaque monkeys. Nine neurons responded to expressions independent of identity and these were found in the superior temporal sulcus. By contrast, fifteen responded to identity, regardless of facial expression. These were mainly located in the inferior temporal gyrus.

In an fMRI study, Puce and co-workers (1998) established that moving faces preferentially activated the human lateral temporal cortex, in comparison to static faces, which led to the conclusion that this neural region may find parts of the face more salient than the whole. Since identity is stable, yet facial expressions are constantly changing, Puce and co-workers may have provided evidence for a neural mechanism that may distinguish between processing of identity and expressions.

1.5.2 Independent neural pathways for specific emotions – a proposal

A topical and controversial debate in neuropsychology is whether a single, unifying model can explain emotion. Some primary views regarding the brain mechanisms involved in emotion have been presented in Section 1.2.1. Furthermore, it has been suggested that the right hemisphere mediates all emotions (Tucker, 1981). A second theory posits that the brain organises emotions differently as a function of valence: the right hemisphere may process negative emotions and the left hemisphere processes positive emotions (Sackheim et al., 1982). The basal ganglia have been implicated in the expression and recognition of emotions, from both the face and the voice (Cancelliere & Kertesz, 1990).

Many researchers take the perspective that there are discrete neural substrates for the recognition of each basic emotion. Research has focused on the aforementioned basic emotions, described by Ekman and Friesen (1971), since these are considered to be pan-cultural and therefore, may result from innate mechanisms that have their bases in neural architecture. Research salient to this proposal will be discussed in Section 1.5.2, and evidence in conflict with this proposal will follow (Section 1.5.3).

Research relevant to the findings reported in this thesis will be reviewed; this includes explorations regarding the neural basis of fear and disgust exclusively.

1.5.2a Amygdala and fear processing – neuropsychological evidence

Close links have been established between fear and the amygdala. The amygdala is a set of subcortical nuclei that lie beneath the temporal lobe. It receives inputs from multiple modalities, not simply the visual domain (Amaral, Price, Pitkanen, & Carmichael, 1992). It is extensively interconnected with the frontal cortex, mediodorsal thalamus and the medial striatum (see Figure 1.2). This makes it an ideal structure to co-ordinate or integrate neural signals from structures involved in emotion processing from multiple communication channels (Nahm, Tranel, Damasio, & Damasio, 1993).

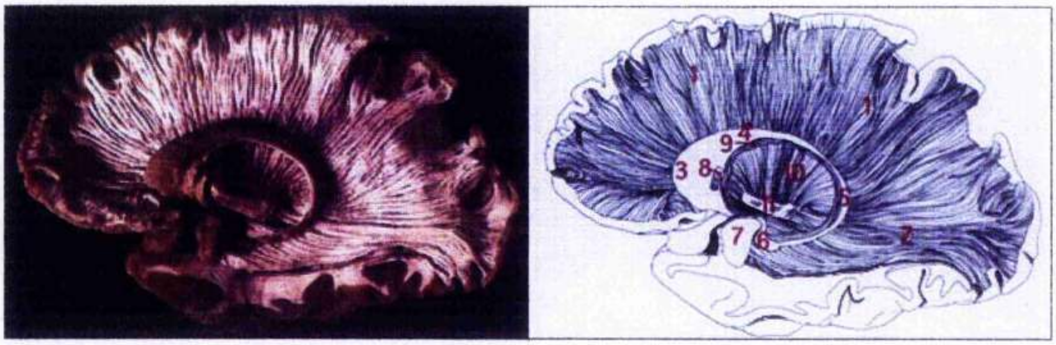


Figure 1.2: Amygdala and its neighbouring structures.

*1. Corona radiata 2. Sagittal striatum 3. Head of caudate nucleus 4. Body of caudate nucleus 5. Tail of caudate nucleus 6. Connecting piece between lentiform nucleus and tail of caudate nucleus 7. **Amygdaloid body** 8. Anterior commissure 9. Stria terminalis 10. Internal capsule 11. Cut surface of basis pedunculi. Source:* http://www.vh.org/Providers/Textbooks/BrainAnatomy/BrainAnatomy.html

Animal studies have revealed that lesions to the amygdala and temporal lobe interfere in the acquisition and display of fearful responses (Klüver & Bucy, 1939). 'Klüver-Bucy syndrome' is characterised in monkeys by tameness and loss of fear primarily. This attenuated expression of fear and aggression is also demonstrated in monkeys with lesions restricted to the amygdala (Weiskrantz, 1956). Researchers have concluded that the amygdala has some involvement in the appraisal of threat and danger. See Calder and colleagues (2001) for a detailed review. Symptoms of

Klüver-Bucy syndrome have been demonstrated in brain-injured humans, in whom some degree of bilateral damage has occurred to the amygdala and inferior temporal cortex. Neuropsychological studies have indicated that bilateral amygdala damage interferes with the recognition of fear from facial displays, while leaving recognition of most other basic emotions from facial displays relatively unaffected in comparison with normal participants or participants with brain damage sparing the amygdala (Adolphs, Tranel, Damasio, & Damasio, 1994; Adolphs, Tranel, Damasio, & Damasio, 1995; Broks et al., 1998; Calder et al., 2001; Calder, Young, Rowland et al., 1996). The amygdala patients have no problems identifying familiar people, or describing a fearful situation. While damage to this structure is associated with disproportionate impairments in perceiving fear, it also results in difficulties in perceiving anger from faces (Adolphs et al., 1999; Calder, Young, Rowland et al., 1996). This fits with the idea that the region is involved in the appraisal of threat.

If the amygdala has a role in threat evaluation, since threat is not only presented visually, but sometimes auditorily as well, this structure would be expected to act as some sort of multi-modal mechanism for threat processing. Neuropsychological research has indicated that the role of the amygdala in emotion processing may not be restricted to facial emotion: Scott and colleagues (1997) have shown that when emotions are conveyed nonverbally (such as screaming), bilateral amygdala damage compromises recognition of fear and anger. In addition, following bilateral amygdala damage, interpretation of fear is not simply impaired from facial and vocal domains, but also from static body posture cues (Sprengelmeyer et al., 1999).

Unlike monkeys, humans suffering from amygdala damage can express fear (Anderson & Phelps, 2000), yet they often exhibit inappropriate responses to fearful situations, which is indicative of a link between experience, expression, and recognition of emotions (Adolphs et al., 1999). Perhaps a more central mechanism fundamental to the experience of fear is compromised by amygdala damage. Amygdala cases enhance the argument that one particular neural region exists, which is responsible for fear processing from multiple modalities. Nevertheless, a deficit for not just fear and anger, but recognition of other negative emotions is often compromised following amygdala damage. Please refer to Section 1.5.3b for more information.

1.5.2b Amygdala and fear processing – a functional imaging perspective

Imaging techniques such as fMRI and PET have also examined the brain processes involved in fear perception. The amygdala shows more activity in response to facial displays of fear when compared to responses to neutral faces, (Breiter et al., 1996; Hariri, Bookheimer, & Mazziotta, 2000; Phillips, Young et al., 1998; Phillips et al., 1997; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). Elevated amygdala activity is associated with fearful faces and voices in comparison with disgust faces (Phillips, Young et al., 1998; Phillips et al., 1997) and in comparison with happiness facial stimuli (Morris, Friston et al., 1998; Morris et al., 1996; Whalen et al., 1998). From a number of studies, Calder and co-workers (2001) summarised the maximally activated voxels involving the amygdala in response to the presentation of fear faces. They reported a propensity for left amygdala activity in response to facial expressions, while fearful displays engage the amygdala bilaterally. Fearful facial displays especially involve dorsal amygdala activity. Phelps and co-workers (2001) manipulated experimental conditions, so that participants thought that they would receive a shock (threat) when a particular coloured square was presented. In this condition, skin conductance levels changed and there was significant activity within the left amygdala.

LeDoux (1989) proposed a fear reaction system, in which threat signals are transmitted from the thalamus to the amygdala (fast subcortical route) and from the sensory cortex to the amygdala (the cortical route). Indeed, support for the subcortical route has come from numerous studies (DeGelder, Vroomen, Pourtois, & Weiskrantz, 1999; Morris, DeGelder, Weiskrantz, & Dolan, 2001; Morris, Öhman, & Dolan, 1998, 1999). These studies suggest that cortical blindness or lack of conscious awareness of threat-related stimuli do not prevent activity in the amygdala in response to the visual presentation of fearful faces. In contrast, Phillips and collaborators (2004) demonstrated that overt presentation of fear stimuli (170ms) is crucial to activating the amygdala, yet short presentation (30ms) is insufficient to trigger responses of this structure.

Imaging studies have supplemented neuropsychological research, providing evidence for amygdala involvement in cross-modal fear perception, since facial *and* vocal expressions of fear activated the amygdala and superior temporal gyrus (Phillips, Young et al., 1998). Morris and colleagues (1999) reported a decreased response in the amygdala and left anterior insula for fearful voices in comparison to sad, happy, and neutral voices. Thus, while the type of response differs, the amygdala is associated with listening to fearful voices in both of these studies.

1.5.2c Neural substrate for fear processing – a summary

In summary, neuropsychological studies of people with damage to the amygdala have indicated that this structure plays some role in fear recognition, since these people have difficulty recognising fear displayed by others and to a lesser extent, experiencing it themselves (Adolphs et al., 1994; Adolphs et al., 1995; Adolphs et al., 1999; Broks et al., 1998; Calder et al., 2001; Scott et al., 1997; Sprengelmeyer et al., 1999; Wang et al., 2002). Functional imaging research has supported this, by showing that the amygdala is activated when participants are exposed to threat-related stimuli (Morris, Friston et al., 1998; Morris et al., 1996; Morris, Öhman et al., 1999; Morris, Scott et al., 1999; Phillips et al., 1999; Phillips, Young et al., 1998; Sprengelmeyer et al., 1998). Please see Sections 1.5.3a-1.5.3b for discussion of the shortcomings of the amygdala theory.

1.5.2d Basal ganglia, insula cortex, and disgust processing – a neuropsychological perspective

There is strong evidence for the involvement of the insula cortex and basal ganglia in emotion processing. Their role is not clear, but research has posited that these regions are related to understanding and expressing emotions (Cancelliere & Kertesz, 1990). The basal ganglia are a collection of nuclei, which include the striatum (the caudate nucleus, putamen, nucleus accumbens), global pallidus, substantia nigra and the subthalamic nucleus (see Figures 1.3 and 1.4).

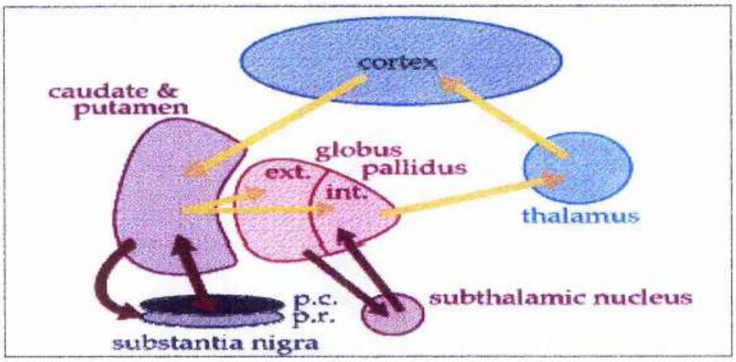


Figure 1.3: The connections of the basal ganglia.

p.c. - substantia nigra pars compacta. p.r. - substantia nigra pars reticulata.

Source: http://thalamus.wustl.edu/course/

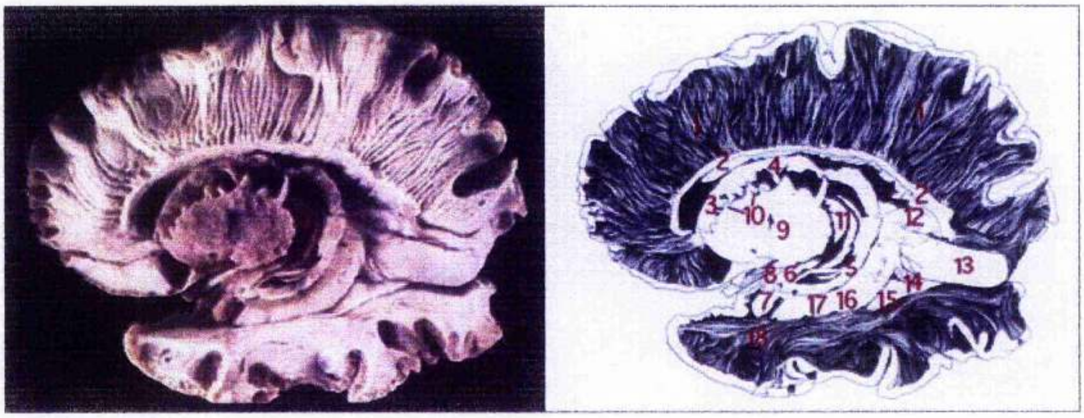


Figure 1.4: The basal ganglia.

***1.** Corona radiata. **2.** Corpus callosum. **3.** Head of caudate nucleus. **4.** Body of caudate nucleus. **5.** Tail of caudate nucleus. **6.** "Foot" of lentiform nucleus. **7.** Amygdaloid nuclear complex. **8.** Optic tract. **9.** Putamen. **10.** Bridges of grey matter between putamen and caudate nucleus. **11.** Pulvinar of thalamus. **12.** Bulb of occipital horn of lateral ventricle. **13.** Calcar avis. **14.** Collateral trigone. **15.** Collateral eminence. **16.** Hippocampus. **17.** Inferior longitudinal fasciculus. **18.** Short arcuate fibers.*

Source: http://www.vh.org/Providers/Textbooks/BrainAnatomy/BrainAnatomy.html

Double dissociations in neuropsychological research provide further support for the hypothesis that there are independent mechanisms underlying the processing of specific emotions. In contrast to fear research, the emotion of disgust has been associated with a distinctly different neural correlate. Huntington's disease is a severe neurogenetic disorder, characterised by late-onset degeneration of the striatum. Patients suffering from Huntington's disease experience impaired recognition of facial expressions of disgust in comparison to other facial expressions of emotion

(Sprengelmeyer et al., 1996; Sprengelmeyer, Young, Sprengelmeyer et al., 1997; Wang, Hoosain, Yang, Meng, & Wang, 2003). Fear perception remains relatively intact, thus a double dissociation between fear and disgust processing has been claimed. The same facial tasks administered to amygdala patients (Broks et al., 1998; Calder, Young, Rowland et al., 1996; Sprengelmeyer et al., 1999) were used in these experiments. Sprengelmeyer and colleagues (1996) also reported that Huntington's patients had abnormal performance in a task assessing disgust recognition from vocal cues. Moreover, the presence of the gene mutation responsible for the development of Huntington's disease leads to problems in perceiving facial disgust, even when the symptoms of this illness are not present (Gray, Young, Barker, Curtis, & Gibson, 1997). A degree of basal ganglia degeneration is associated with this state. These studies provide neuropsychological evidence for some role of the basal ganglia in disgust processing.

Abnormal metabolic activity within the basal ganglia is observed in cases of Obsessive-Compulsive Disorder (OCD) and Tourette's syndrome (Braun et al., 1995; Rapoport, 1989; Rapoport & Fiske, 1998). OCD is a complex, heterogeneous anxiety disorder, defined by presence of either self-recognised irrational or unreasonable obsessions or compulsions, which affect everyday functioning. Tourette's syndrome is a tic disorder that is characterised by early onset and social or occupational functioning impairment and often includes OCD-type behaviours (APA, 1994; Braun et al., 1995). Interpretation of facial displays of disgust is also disturbed in OCD and Tourette's, but only if OCD symptoms are detected in its diagnosis (Sprengelmeyer, Young, Pundt et al., 1997). Sprengelmeyer and colleagues suggested that the presence of obsessive-compulsive behaviours is a defining feature of the disgust deficit.

Dysfunction in regions of the basal ganglia, particularly the striatum and the substantia nigra, also occurs in Parkinson's disease. Consequently, research has focused on whether there are interferences in the processing of disgust stimuli in patients with this disease. Unmedicated Parkinson's patients were significantly worse at perceiving facial disgust than their medicated counterparts and a control group (Sprengelmeyer et al., 2003). This disgust deficit, specific to faces, has been reported in another study (Kan, Kawamura, Hasegawa, Mochizuki, & Nakamura, 2002). Facial and vocal fear recognition accuracy combined is impaired in Parkinson's patients with bilateral Parkinson's disease (Yip, Lee, Ho, Tsang, & Li, 2003). Yet groups with Parkinson's symptoms exhibited on their right side were less accurate at perceiving disgust and sadness from the facial and vocal channels pooled together.

Disgust is believed to have evolved in order prevent us from ingesting harmful substances and to communicate this danger to others (Rozin, Haidt, & McCauley, 2000). Thus, one would expect this emotion to involve multiple sensory inputs. In a neuropsychological case study, an individual with insula cortex and putamen damage had great difficulty recognising disgust from faces *and* from voices, both from non-verbal cues and prosodic cues (Calder, Keane, Manes, Antoun, & Young, 2000). Yet he *understood* what was meant by disgust. Thus, the concept and recognition do not seem to be related. The basal ganglia and insula are highly interconnected. Adolphs and colleagues (2003) also examined a participant with extensive neural damage, particularly to the insula cortex, and found him to have profound difficulties in perceiving disgust from dynamic facial expressions and emotional descriptions, and he seemed to have an abnormal experience of this emotion. These two studies imply that when the insula-striatal system is compromised, disgust processing is impaired, thus indicating a role for this system in disgust processing. It is also important to note that an abnormal increase in activation of insula in response to sensory processing and movement processing is also associated with Huntington's disease (Boecker et al., 1999; Weeks et al., 1997). Thus, the insula cortex would be a suitable candidate for processing disgust. It has also been labelled as the gustatory cortex since it contains neurons that respond to pleasant and unpleasant tastes (Small et al., 1999; Yaxley, Rolls, & Sienkiewicz, 1988). This is fitting, given the proposed phylogenetic origins of disgust as a rejection response to bad tastes (Rozin et al., 2000). Therefore, disgust seems to be linked with gustation and the insula cortex. There are studies that conflict with the proposal that disgust is processed by a separable neural mechanism, however. Please see Sections 1.5.3c-1.5.3d.

1.5.2e Basal ganglia, insula cortex, and disgust processing – a functional imaging perspective

Functional imaging studies have been particularly informative because the brain regions involved in disgust are not clear; Huntington's and Parkinson's disease, and

OCD are not associated with overlapping or selective neural degeneration. fMRI was used to compare neural activity when participants viewed neutral and disgusted faces. Strong and mild expressions of disgust activated the insula and basal ganglia nuclei (Phillips et al., 1997). The amygdala was not activated by disgust. This provides a further evidence for separable structures involved in fear and disgust processing. Extensions of this work revealed that the anterior insula, the caudate, and putamen were involved in facial disgust perception (Phillips, Young et al., 1998; Sprengelmeyer et al., 1998). Recordings of intracerebral event-related potentials further revealed the importance of the ventral anterior insula in the perception of facial expressions, particularly those representing disgust (Krolak-Salmon et al., 2003).

A recent fMRI exploration has examined the neural activity of a group of pre-symptomatic Huntington's disease gene-carriers when disgusted faces were exhibited (Hennenlotter et al., 2004). Gene carriers had reduced responses within the left dorsal anterior insula in response to disgusted but not surprised or neutral faces, which in control participants showed an increase in activation. Behaviourally, the gene carriers were impaired in perceiving disgust. This study provides additional evidence for the role of the insula cortex in the processing of disgust.

Furthermore, disgusting pictures also seem to activate the insula cortex (Phillips et al., 2000). Heining (2003) found that the insula responded to the presentation of disgust in auditory, gustatory, visual, and olfactory channels. This suggests that there may be some sort of multi-modal system for processing disgust, which involves regions of the insula and basal ganglia. Various research contests this idea, however. Please see Section 1.5.3c.

1.5.2f Neural substrate for disgust processing – a summary

In summary, disgust has been associated to neural structures including the insula cortex and the basal ganglia, but *not* the amygdala. Neuropsychological studies have provided strong support for the role of the basal ganglia and insula cortex in disgust processing (Adolphs et al., 2003; Calder, Keane, Manes et al., 2000; Gray et al., 1997;

Sprengelmeyer et al., 1996; Sprengelmeyer, Young, Pundt et al., 1997; Wang et al., 2003).

The studies presented in Section 1.5.2e support the neuropsychological proposal that processing facial disgust may be separable from fear processing; and that disgust perception may rely on the insula or basal ganglia (Hennenlotter et al., 2004; Phillips et al., 2000; Phillips, Senior, Fahy, & David, 1998; Phillips, Young et al., 1998; Phillips et al., 1997; Sprengelmeyer et al., 1998).

1.5.3 A case for questions against independent neural pathways for specific emotions

Despite the research outlined above, there is also a case against the concept of partially distinct pathways for processing fear and disgust regardless of modality.

1.5.3a Amygdala and imaging studies

Substantial evidence links the amygdala to fear processing, but also to the processing of most facial expressions of emotions (Phan, Wager, Taylor, & Liberzon, 2002). For instance, fMRI and PET studies have shown that activation of the amygdala changes in response to angry, sad, happy, and disgusted faces not just fearful faces (Blair, Morris, Frith, Perrett, & Dolan, 1999; Breiter et al., 1996; Gorno-Tempini et al., 2001; Hariri et al., 2000; Morris, Friston et al., 1998; Whalen et al., 1998). No specific distinctions between amygdala activation in the processing of different emotions could be reported in another study (Winston, O'Doherty, & Dolan, 2003). Crying and laughter (which are associated with sadness and happiness) have been found to strongly activate the amygdala bilaterally and the insula cortex (Sander, Brechmann, & Scheich, 2003; Sander & Scheich, 2001). Davis and Whalen (2001) suggested that the amygdala may have a more general role in emotion processing, such as evaluating salience of stimuli.

1.5.3b Amygdala and neuropsychological studies

Neuropsychological research also demonstrates a more multifarious role for the amygdala in emotion processing. For example, Phelps and Anderson (1997) have reported that interpretation of sadness and disgust, along with fear is impaired in populations following amygdala damage. Two case studies, whilst reporting that amygdala lesions are associated with disproportionate reductions in recognition of fear, also reported impairments in perceiving sadness (Sprengelmeyer et al., 1999) and disgust (Wang et al., 2002). Adolphs and collaborators (1995) reported that right amygdala damage resulted in no marked impairments in the recognition of specific emotions, and left amygdala damage led to impairments in the recognition of most facial emotions. Yet bilateral amygdala damage does not always give rise to fear recognition deficits either (Hamann et al., 1996). The culmination of this research suggests that the amygdala has a more complex role in emotion processing than simply an involvement in the processing of fear stimuli.

Rapcsak and his colleagues (2000) carried out a comprehensive study with sixty-three patients who were suffering from a wide range of neurological damage. Patients who exhibited difficulties in perceiving particular facial emotion did not suffer from any clear pattern of brain damage. Furthermore, the amygdala was not associated with deficits in fear processing, but more with general problems in emotion processing. Rapcsak and collaborators suggested that disproportionately poor recognition of fear displays described in other research might be explained by an exacerbation of normal task difficulty in patients suffering from amygdala damage. This study provides evidence to suggest that the amygdala is not a modular system for processing fear or threat selectively.

The amygdala has been proposed to be part of a defence mechanism involved in the appraisal of threat. Since threats are not only visual, this mechanism would be expected to function across communication channels. Yet the involvement of the amygdala in vocal perception of fear is by no means an established finding. For instance, selective amygdala damage may impair recognition of facial but not vocal fear (Adolphs, Damasio, & Tranel, 2002; Anderson & Phelps, 1998). The opposite pattern was reported by Ghika-Schmid and colleagues (1997): in patients suffering from bihippocampal damage, facial fear processing was intact, but not vocal fear processing. This neuropsychological evidence suggests that non-verbal channels for fear recognition are partially dependent on different brain structures. This is discrepant with other neuropsychological research, and further suggests that amygdala involvement in emotion processing is not fully understood.

In accordance, though bilateral amygdala damage has been associated with impaired facial and vocal deficits in fear perception (Scott et al., 1997), it has been reported that for the vocal stimuli used in this study, the healthy control group found fear the most difficult emotion to perceive (Scott, personal communication). If the effects of task difficulty are worsened by amygdala damage, this could also explain the disproportionate influence on vocal fear perception in this task.

Adolphs and Tranel (2003) observed that amygdala patients had difficulties only with recognising negative emotions, particularly anger, when expressed by the face. They had no difficulties when these emotions were represented by inferred body movements and positions (with faces obscured) in still images from films. For instance, one image showed a person about to strike another, and the victim cowering in fear. When facial expressions were included in these scenes, this confounded their recognition. It could be postulated that amygdala association with fear perception might be restricted to facial perception only.

In the light of this finding, a point made by Meadows (1974) in the context of prosopagnosia should be considered here. He suggested that any residual capacity of the intact brain regions (normally competent) to complete a task might not be sufficient enough for accurate processing, perhaps as a consequence of inhibition by the damaged region. In support of Meadows' suggestion, Perrett (personal communication) presented famous faces to the right visual field of a prosopagnosic patient and found evidence for some remaining intact left hemisphere face processing, but when faces were presented to the whole unrestricted visual field, the patient could not recognise the faces. Thus, it is likely that the patient's damaged right hemisphere prevented the intact left hemisphere from being accessed. This could be related to the emotion perception studies. It is possible that the patients described in Adolphs and Tranel's (2003) study might have some remaining ability to complete the emotion scene perception task, but when the incapacitated amygdala becomes involved (due to the inclusion of faces), it affects the task's accomplishment.

1.5.3c Basal ganglia, insula cortex, and imaging studies

It is not only research focusing on the amygdala that has encountered scrutiny of late. Basal ganglia and insula activity have been associated with processing of emotions other than disgust. Observing happy face activates the basal ganglia, particularly the ventral striatum and putamen (Morris, Friston et al., 1998; Morris et al., 1996; Phan et al., 2002; Phillips, Bullmore et al., 1998; Whalen et al., 1998). Happiness-related stimuli also trigger responses in these regions (Lane, Chua, & Dolan, 1999; Lane, Reiman, Ahern, Schwartz, & Davidson, 1997). Phelps and co-workers (2001) reported that the insula responded to the production of several emotions, not simply disgust, and they suggested that the insula may act to integrate emotional information. Moreover, Schienle and colleagues (2002) reported that the insula was activated in response to fearful, as well as disgusting, images.

In contrast with the view that disgust might operate multi-modally, facial and vocal communication channels seem to be dissociated. Imaging studies have failed to reveal basal ganglia or insula cortex involvement during the presentation of vocal disgust s(Phillips, Young et al., 1998). This contrasts with results following facial disgust presentations. Moreover, Heining (2003), Yaxley and colleagues (1988), and Small and collaborators (1999) report that the insula responds not simply to bad tastes, but to pleasant tastes as well.

1.5.3d Basal ganglia, insula cortex, and neuropsychological studies

In the populations described in Section 1.5.2d, who have a difficulty in perceiving disgust, fear perception is also affected. For instance, Sprengelmeyer and colleagues (1996) also found that Huntington's Disease patients were significantly worse than healthy individuals at recognising all negative emotions, despite focusing on the disturbance in disgust processing. Reanalysis of Gray and colleagues' (1997) data indicate a greater deficit in fear perception than disgust perception (Milders, Crawford, Lamb, & Simpson, 2003). Milders and co-workers (2003) also examined a population suffering from Huntington's disease and they failed to replicate the disgust deficit reported by Sprengelmeyer and colleagues (1996; 1997). Indeed, Milders and colleagues reported that recognition of all negative emotions was affected, in particular fear, which they accredited to task difficulty. In addition, while a disgust deficit in Parkinson's disease patients was focused on, Sprengelmeyer and colleagues (2003) also found a fear impairment in all Parkinson's patients.

Further neuropsychological studies contest the proposal that there are specialised neural substrates for emotion processing from multiple channels. Kan and collaborators (2002) explored emotion perception in Parkinson's disease. Parkinson's patients were significantly worse than healthy participants in their perception of facial fear and disgust. This did not extend to prosodic or written stimuli. All static facial displays were particularly hard for the Parkinson's disease participants to identify. The dissociation between Parkinson's disease patients' abilities on these different tasks indicates that the neural substrates implicated in emotion processing may not be the same for emotions expressed by different channels. Neuropsychological studies exploring the processing of vocal disgust are limited in other population groups, such as Huntington's disease patients, so it is unclear whether a deficit in recognition of this form of stimuli could be replicated.

As noted earlier, Huntington's disease, Tourette's disorder, and OCD are not characterised by the same neuropathology. Since these disorders have been related to a disgust perception deficit, it is difficult to conclude that disgust is processed by a unitary neural mechanism, particularly as the actual brain regions associated with disgust deficits in neuropsychological populations are unclear. Furthermore, the disgust recognition deficit observed in OCD has not been replicated (Kornreich et al., 2001; Parker, McNally, Nakayama, & Wilhelm, 2004). Perhaps a disgust deficit is confined to an undefined subset of OCD sufferers.

While some neuropsychological and imaging studies provide support for a link between visual and vocal disgust recognition, there are still a number of discrepant research findings. The issue whether disgust is processed supramodally is not resolved.

1.5.3e Complex neural systems

As a result of the inconsistencies in research, it has been acknowledged by most researchers that the neural systems involved in emotion are more complex than simply distinct circuits underlying the processing of each emotion. The neural mechanisms associated with emotion may involve overlapping networks, rather than being wholly distinct. As a result of these overlapping circuits, some mechanisms may be disproportionately involved in the processing of one emotion more than others.

1.5.4 Mirror neurons and emotion processing

Mirror neurons have been explored in non-human primates, namely macaques. They respond during execution of a goal-directed action, and also when this same action is observed being performed by someone else (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Gallese & Goldman, 1998; Keysers et al., 2003; Kohler et al., 2002; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996; Rizzolatti, Fogassi, & Gallese, 2001). This system might not be restricted to object-oriented actions, such as grasping or ripping actions, but also to communicative gestures shown in monkeys, such a lip-smacking or tongue protrusion (Ferrari, Gallese, Rizzolatti, & Fogassi, 2003). Evidence for a mirror system can be found in human brains (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995). In humans, however, the mirror-neuron system has different properties to those in animals. For instance, meaningless movements and movements that comprise an action activate this system in humans, but not in monkeys (Rizzolatti & Craighero, 2004). This has been regarded as support for proposals that, as a species, humans have the ability to learn via imitation.

Perhaps perception of emotion is dependent on matching an emotion and how it would feel, via an internal simulation of its characteristic expression (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Gallese, Keysers, & Rizzolatti, in press). Interpreting another person's nonverbal cues to emotion could involve activity of mirror neurons.

There is growing evidence that the mirror system matches more than action execution and visually presented actions. Kohler and colleagues (2002) described a set of mirror neurons with both visual *and* auditory properties. They reported that some neurons in monkeys' ventral premotor cortex respond when the monkey executes an action, when it observes an action executed by someone else, and when it hears the corresponding noise associated with that action, even though it cannot see the action being carried out. Further evidence for the receptive aspects of audiovisual properties of mirror neurons has been presented by other researchers (Barraclough, Xiao, Baker, Oram, & Perrett, in press; Calvert & Campbell, 2003).

Fadiga and co-workers (2002) used transcranial magnetic stimulation (TMS) to explore the relationship between vocal expression and perception in humans. This is based on a proposal by Liberman and Whalen (2000) that the phonetic elements of speech, underlying linguistic communication, are not sounds but rather the articulatory gestures that generate those sounds. In order to understand speech, the sounds of speech would activate the listener's articulatory gestures representations (motor representation). Participants took part in a speech listening task, which involved listening to a variety of sounds, words, and pseudo-words. Threshold for tongue movements triggered by TMS to motor cortex was reduced by listening to speech sounds that relate specifically to those tongue movements. Similar findings were also reported by Wilson and colleagues (2004).

A similar mechanism to that which governs action perception (both auditory and visual) and execution, involving viscero-motor regions, has been proposed to underlie understanding of others' emotions. Specifically, there is evidence to suggest that humans model internally or match another's state onto our own corresponding neural representation for that state, in order for us to assign a label to this state (Gallese & Goldman, 1998). For more information on this simulation theory approach, please refer to Goldman (1992), Gordon (1996), and Gallese and colleagues (in press).

Further evidence for the link between perception and expression can be demonstrated; when others are observed expressing emotion in their face, researchers report that humans have a tendency to involuntarily activate the same muscles involved in that expression within their own face (Dimberg & Lundquist, 1990; Greenwald, Cook, & Lang, 1989; Schwartz, Brown, & Ahern, 1980).

Wicker and colleagues (2003) provided imaging support for this theory, linking perception and expression. Feelings of disgust induced by unpleasant odours activated the anterior insula and anterior cingulate cortex. These regions were also activated when facial expressions associated with feelings of disgust were observed visually. In several neuropsychological cases, patients, who have disturbed perception of particular emotions, also suffer disturbances in their experience of those emotions. This confirms a close relationship between experience and identification. Mirror neurons might be activated when emotions are perceived in others and when experiencing that emotion oneself, perhaps helping emotion recognition.

Further links between emotion perception and premotor (including the frontal operculum) and somatosensory cortices (which may be included in mirroring) have been reported. Kesler-West and collaborators (2001) observed that the frontal opercular cortices were activated in response to emotional facial expressions. This was also reported by Adolphs and co-workers (2000), who, in addition, found integrity of right somatosensory cortices is important for the recognition of emotional expressions. Winston and colleagues (2003) observed activation of somatosensory cortices in response to facial emotion. This activation is not restricted to reactions to facial expressions, but activity also occurs in response to presentation of prosody (Adolphs et al., 2002). Thus, it is reasonable to postulate the role of a mirror neuron system in the processing of a range of emotional stimuli.

Familiarity with your own emotional displays would improve recognition of others' emotions. This idea is strengthened by the work of Grèzes and collaborators (2004), who reported that participants' action-related neural regions were activated earlier when viewing their own pre-recorded body movements than when viewing the movements of others. This suggests that participants may recognise familiar movements more quickly, based on familiarity with their own production of such signals.

Neurons that process actions and inferred actions are found along the superior temporal sulcus (STS), and this region is activated in response to an array of stimuli. This region is not considered to be part of the mirror neuron system, since it lacks motor properties, (Rizzolatti & Craighero, 2004); the STS responds to sensory input, but not executed action. Nevertheless, this region may play a role in the interpretation of emotional stimuli. For instance, human vocal information triggers changes in activity along the STS (Belin, Fecteau, & Bédard, 2004; Belin, Zatorre, Lafaille, Ahad, & Pike, 2000; Gervais et al., 2004). Moreover, viewing dynamic, and to a lesser extent, still speech patterns, without the corresponding auditory display also is characterised by a Blood Oxygen Level Dependent response in STS (Calvert & Campbell, 2003). Thus, STS neuron activity appears to be important in the processing of human vocal patterns. In addition, the STS is activated when body movements are presented visually (Allison, Puce, & McCarthy, 2000; Bonda, Petrides, Ostry, & Evans, 1996; Grossman et al., 2000; Howard et al., 1996; Puce & Perrett, 2003). Saxe and Kanwisher (2003) provided evidence for a degree of STS neural activity during stories in which biological movement was described. Together, these research studies suggest that the processing of verbal and nonverbal cues are related to STS neuron activity, thus interpretation of emotions, if presented nonverbally, may well involve this system.

In summary, this research shows that mirror neurons are involved in the processing of vocal information and nonverbal cues from others (e.g. body movements), and also when the participant executes these verbal and nonverbal behaviours themselves. Since many emotional cues are nonverbal, it is likely that the processing and communication of these signals might involve STS neurons; the STS may provide the sensory input to the mirror system. In turn, interpretation of these sensory cues may engage mirror neuron system structures. This mirror system may enable comprehension of emotion displayed by others, and elements within the system may allow the differentiation of fear, disgust, anger, happiness, sadness, and so on, performed by others. The system, as a whole, however, is unlikely to be designed for one particular emotion.

1.5.5 Expression versus recognition of emotions

While the above proposal suggests than motor imagery is related to the interpretation of emotions, there is substantial literature describing an impairment in emotion recognition but not in emotion expression abilities. Please see Anderson and Phelps (2000), for instance. This is indicative of dissociable mechanisms responsible for processing emotion – one that has its roots in perceiving and interpreting emotion; and one that is responsible for expressing emotion, which seems to be unaffected in these instances. Expression may be independent of motor imagery.

1.6 Limitations of emotion research

1.6.1 Modality of stimuli

One of the key criticisms for the theory that emotions have evolved for functional purposes and, as such, are processed by somewhat independent neural structures, is that research examining emotion recognition from multiple modalities is limited. Generally, most neuropsychological research has focused purely on interpretation of facial emotion, and the conclusions of the few studies examining vocal emotion perception have been mixed. The face is believed by several researchers to convey more information than other emotional cues, such as those communicated by voice or body gestures. Yet, relatively little is actually known about the processing of other forms of emotional expression. To what extent neural systems may be specialised for processing cross-modal emotional stimuli has not been addressed comprehensively. Therefore, it would be beneficial to investigate the neural structures associated in processing different types of vocal emotional expressions and also emotion expressed from other visual cues, such a gestures. Drawing conclusions regarding emotion processing multi-modally on the basis of one channel of communication may be misguided.

Facial emotion perception is favoured as a research tool, since it has been demonstrated to be effective cross-culturally, yet vocal expressions and gestural expressions of emotion are also believed to be universal (Elfenbein & Ambady, 2002; Hejmadi, Davidson, & Rozin, 2000; Montepare & Zebrowitz, 1993; Scherer, Banse, & Wallbott, 2001).

1.6.1a Vocal emotion perception

The voice can convey a wealth of information as well as the face, but this mode of communication has been neglected to an extent in emotion research. This lack of research reflects the practical and technical complexities of studying expression and perception of vocal emotions. Research that has examined vocal expression of emotion has used several different types of stimuli, which could explain contradictory results. For example, some studies examine perception of non-verbal sounds, such as growls, screams, and laughter, while others examine responses to verbal expressions – this can vary from one word being spoken with different types of emotional inflection, to whole sentences. Alternatively, some studies have investigated vocal expressions of emotion presented in meaningless sentences, or nonsense-words. The voice is a fundamental conveyor of emotion. Darwin (1872) said that 'with many kinds of animals, man included, the vocal organs are efficient in the highest degree as a means of expression' (page 88).

The argument that each emotion might be processed by a separable neural mechanism suggests that should someone be impaired at recognising a specific facial emotion, that particular emotion will also be more difficult to recognise when expressed vocally. There is substantial evidence for simultaneous and linked visual and auditory perception. For instance, when a speaker is seen, speech comprehension is enhanced (Sumby & Pollack, 1954). Moreover, the McGurk effect is a well-known paradigm, whereby visual cues interfere in the perception of auditory cues (McGurk & MacDonald, 1976). If a vocal sound is presented simultaneously with an incongruent facial movement display, then this significantly affects the way in which that sound is perceived. If the sound 'ba' is vocalised, but the face is seen to say 'ga', then a receiver would experience the sound 'da', a combination of the two inputs, which shows the influence of both communication channels on perception. Ventriloquism is a further demonstration that there is simultaneous and linked visual and auditory perception. Even the cinema demonstrates how humans combine information they see and hear together: audiences perceive the voices to be coming from the actors on the screen, rather than from speakers around the room. This audiovisual integration provides robust evidence for cross-modal interactions.

1.6.1b Gestural emotion perception

Very little neuropsychological research has investigated the perception of emotional cues from body movements. Again, methodological variations limit the generalisation of research using such stimuli. For instance, emotions can be conveyed by the body using symbolic cues, or natural body movements; some studies have focused on still postures, as opposed to moving gestures and vice versa; other studies present posed expressions and others present spontaneous expressions of emotion. It has been suggested that body language cues are just as effective as facial cues for indicating the intensity of an emotional state (Graham, Bitti, & Argyle, 1975). Dynamic cues enhance perceptive abilities, since still pictures of people displaying emotions with their body are far more difficult to recognise (Walters & Walk, 1988). Negative emotions have been reported as easier to recognise from dynamic video clips (Sogon & Izard, 1987). Fundamental emotions are recognised across cultures when depicted using body movements (De Meijer, 1989; Sogon & Masutani, 1989). Such movements may be valuable for the communication of emotions across distances, where recognition of emotion from facial expressions is difficult (Walters & Walk, 1988). Moreover, Boone and Cunningham (1998) found that children as young as four are able to use a number of cues from body movements to identify sadness, and by the age of five they can interpret fear and happiness represented by the body.

Music and dance are frequently associated with mood and emotional portrayal. Both American and Indian population groups recognised emotion when depicted in an ancient Hindu dance-form (Hejmadi et al., 2000). The style of dance that was employed in this experiment was a classical and ancient Hindu-Indian dance form, which displays ten different emotions, with a great deal of emphasis on hand and body movements. Other studies have shown that emotions are relatively easy to recognise from dance movements (Brownlow, Dixon, Egbert, & Radcliffe, 1997; Dittrich, Troscianko, Lea, & Morgan, 1996; Walk & Homan, 1984).

Point-light displays, in which points at major positions on the body are the only cues visible to the observer, are sufficient to give the impression biological motion (Johansson, 1973). Recognition of emotions portrayed by dynamic point-light displays is very accurate (Dittrich et al., 1996; Walk & Homan, 1984).

Research has demonstrated that body movements can provide information regarding a person's emotional state, and this can be conveyed not simply in normal lighting conditions, but also in point-light conditions. Dynamic body movement stimuli have rarely been incorporated in neuropsychological research, however. One study reported that amygdala damage led to difficulties in perceiving fear and anger depicted in point-light conditions by actors' walking actions (Heberlein, Ravahi, Adolphs, Tranel, & Damasio, 2000). Furthermore, DeGelder and colleagues (2004) and Hadjikhani and DeGelder (2003) indicated (using fMRI) that observing fear represented by body movements activates neural regions involved in fear processing, namely the amygdala.

1.6.2 Underestimating individual differences in emotion perception

The role of individual differences is generally neglected in neuropsychological emotion research. For instance, many studies assume that difficulties in perceiving emotions are related to neural dysfunction rather than other factors, such as mood fluctuations. For the most part, neuropsychologists do try to match patient groups and control participants on the basis of age, sex, and IQ, yet studies do not typically consider the impact of these factors on emotion processing.

1.7 A proposal for research – multiple communication channels and individual differences

In an effort to understand the neural processes involved in multi-modal emotion perception, the research in this thesis will examine emotion perception from a number of communication channels. These include facial displays of emotion, vocal representations of emotion, and dynamic gestural portrayals of emotion. Recognition levels on each of these tasks will be compared and contrasted. Questionnaires assessing emotional experience will also be incorporated. The impact of mood, both state (transient) and trait (more durable), age, and sex of participant and sex of stimulus actor will be investigated. This collection of experiments provides information about the ease with which normal, healthy people perceive and recognise emotions expressed in different modalities, and thus, could offer clues about the phylogeny and ontogeny of emotion recognition.

A clinical exploration of the influence of Parkinson's disease on emotion processing will be presented. This offers a neuropsychological approach to examining the neural mechanisms involved in emotion perception. *Expression* of emotions, both facially and vocally, is severely affected in Parkinson's disease, yet studies on emotion *recognition* from faces and voices remain inconclusive. Basal ganglia dysfunction is associated with Parkinson's disease, and since these structures have been implicated in disgust processing, a comprehensive investigation of the role of the basal ganglia in the processing of emotion from multiple channels will be conducted. Few studies have explored emotion recognition across multiple channels. Should neural mechanisms exist that are specialised for the processing of particular emotions, any deficits shown on one task would be expected to extend to other tasks and across modalities. This information can be used to help determine the nature of the emotional impairment. This also provides an opportunity to examine the role of motor imagery abilities in emotion perception, as motor imagery is believed to be affected by this motor control disorder (Thobois et al., 2000).

Further, understanding deficits in emotion perception can help researchers to comprehend the difficulties faced by clinical groups. Several individuals suffering from clinical disorders are prone to becoming withdrawn and isolated socially. This social change may arise from several issues, but a major contributing factor could result from problems in interpreting emotion of others. Thus, it is of great importance to understand whether deficits in emotion perception could contribute to the development of such interpersonal difficulties, as this could help and guide carers in their everyday interactions with such patients.

1.7.1 A method for assessing emotional impairments

When exploring emotion processing, most studies focus on sensitivity levels for each emotion in order to explore patterns of difficulty. The confusability of the emotions in these tasks is rarely examined, yet this could further our understanding of any impairment shown in the recognition of emotional stimuli. Researchers in favour of a dimensional approach to emotion perception, such that emotions may be related in a highly systematic fashion, have examined false positives in response to labelling emotional stimuli. For instance, Woodworth (1938) examined confusions made between recognition of facial expressions of emotion and this led him to arrange emotions on a circular plane, based upon similarity of the emotional displays. According to this approach, emotions may be part of emotional space, defined by specific dimensions.

Investigating errors and false positives could divulge whether certain populations have a tendency to over-use a particular emotional label more than others, whether they have heightened recognition accuracy for particular emotions, or whether a recognition deficit for a specific emotion exists.

Recently, it has been reported that young people with mood disorders, such as bipolar disorder, have a bias to misinterpret the facial expressions of peers as angry (McClure, Pope, Hoberman, Pine, & Leibenluft, 2003). Furthermore, Frigerio and colleagues (2002) reported that alcoholics interpret sad faces as being hostile (angry or disgusted) more than control participants. Other studies need to explore this mis-labelling of emotions to understand any exhibited impairments fully. A method for exploring these mistakes is proposed in this thesis, whereby false positives and errors are analysed in order to understand patterns of difficulty in emotion processing.

2 EXPERIMENTAL MATERIALS

This chapter will provide an overview of the principal emotional tests employed in the research presented in this thesis.

2.1 Introduction

2.1.1 The need for a comprehensive set of emotion tests

Communicating emotional states is a skill that most humans exhibit. This skill is central to human social interactions, and it essentially directs appropriate behavioural responses for such situations. Expression and recognition of emotion often occur without awareness, yet there seem to be universal patterns in the way in which different emotions are represented through specific channels. For example, facial expressions of happiness have similar basic components that are always displayed, regardless of the country, society, or context in which that emotion is elicited (Ekman & Friesen, 1978). Vocal and gestural expressions of emotion also seem to have universal qualities (Banse & Scherer, 1996; De Meijer, 1989; Elfenbein & Ambady, 2002; Hejmadi et al., 2000; Scherer et al., 2001; Van Bezooijen, Otto, & Heenan, 1983).

There has been a paucity of research exploring emotional recognition, other than interpreting facial expressions. While a set arsenal of reliable, valid, commercially-available instruments for measuring various aspects of emotional face perception exist (Ekman & Friesen, 1976; Matsumoto & Ekman, 1988; Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002), the extent of measures with potential neuropsychological significance for gestural emotion perception and vocal emotion perception is less widespread or established. Yet the face may *not* be the most telling bearer of a person's emotional state. The phylogenetic roots of each emotion may determine that specific emotions are displayed most clearly through particular channels of communication. Cultural display rules may influence this to a certain extent (Ekman & Rosenberg, 1997; Fridlund, 1994; Russell, 1994). The research in this thesis uses a comprehensive set of tests, in order to understand emotion processing from multiple communication channels and the relationships between these channels.

2.2 The tests

The instructions for all tasks are outlined in Appendix 2.

2.2.1 Facial tests

To investigate the perception of facial emotion, two conventional, standardised testing procedures have been used in this thesis from Young and colleagues' (2002) Facial Expressions of Emotion: Stimuli and Test (FEEST).

2.2.1a Ekman 60

2.2.1a (i) Stimuli

The Ekman 60 involves the pseudo-random presentation of achromatic photographs of faces expressing emotions. The photographs portray ten actors, each posing six emotions (anger, disgust, fear, happiness, sadness, and surprise). The faces are originally from Ekman and Friesen's (1976) series. Figure 2.1 shows an example of these stimuli.

Figure 2.1: Examples of Ekman 60 stimuli.

2.2.1a (ii) Procedure

Participants are presented with the 60 faces on a 15" Toshiba Satellite 2410 computer screen. The participants have to indicate which emotion from the list of emotions (anger, disgust, fear, happiness, sadness, or surprise) is expressed in the photograph they are shown. The labels are visible throughout testing. Their responses are recorded by either pressing appropriate keys on the keyboard, or by using the mouse to click buttons on the screen. The participants either do this themselves, or the experimenter does this for them (for the older and clinical participants). The faces are only shown for three seconds each time, and then a blank screen follows, but the participants can take as long as they wish to make their decision. The next face is not presented until a decision about the previous stimulus has been made. No feedback is given regarding their decisions.

2.2.1b Emotion hexagon

2.2.1b (i) Stimuli

The Emotion Hexagon includes computer-manipulated versions of the photos from the Ekman 60 (Young et al., 1997). Graphical alterations were introduced by the morphing of facial expressions together, with the intention that one face is a combination of two different facial expressions. Morphing is a technique that enables images to be interpolated along a continuum between the two prototype images (in this case, pictures of faces with different facial expressions of emotion). The basic technique involves locating specified points on the two images (delineation), and then the shape of one image can be shifted towards that of the other image along a continuum (shape interpolation). The final stage involves producing a continuous-tone image by warping and stretching each face to the new shape.

The expressions morphed together are those that are most regularly confounded, according to Woodworth and Schlosberg's (1954) model of emotional space (happiness-surprise, surprise-fear, fear-sadness, sadness-disgust, disgust-anger, anger-happiness). Therefore, the hexagon is the sequence of facial expressions ordered by their maximum confusability. For example, facial fear and surprise are consistently confused – so these expressions were morphed together. This manipulation of the pictures created a set of faces in which each face is a combination of two emotions.

Within a set of faces there was one face which was 10% of the first emotion, 90% second emotion; one face with 30% first emotion, 70% second emotion; another that is 50% each emotion; one that is 70% first emotion, 30% second emotion; and finally, a face that contains 90% first emotion, 10% second emotion. For more information, please refer to Calder and colleagues (1996) and Young and collaborators (1997). These continua are shown in Figure 2.2. These 30 faces were included in this task.

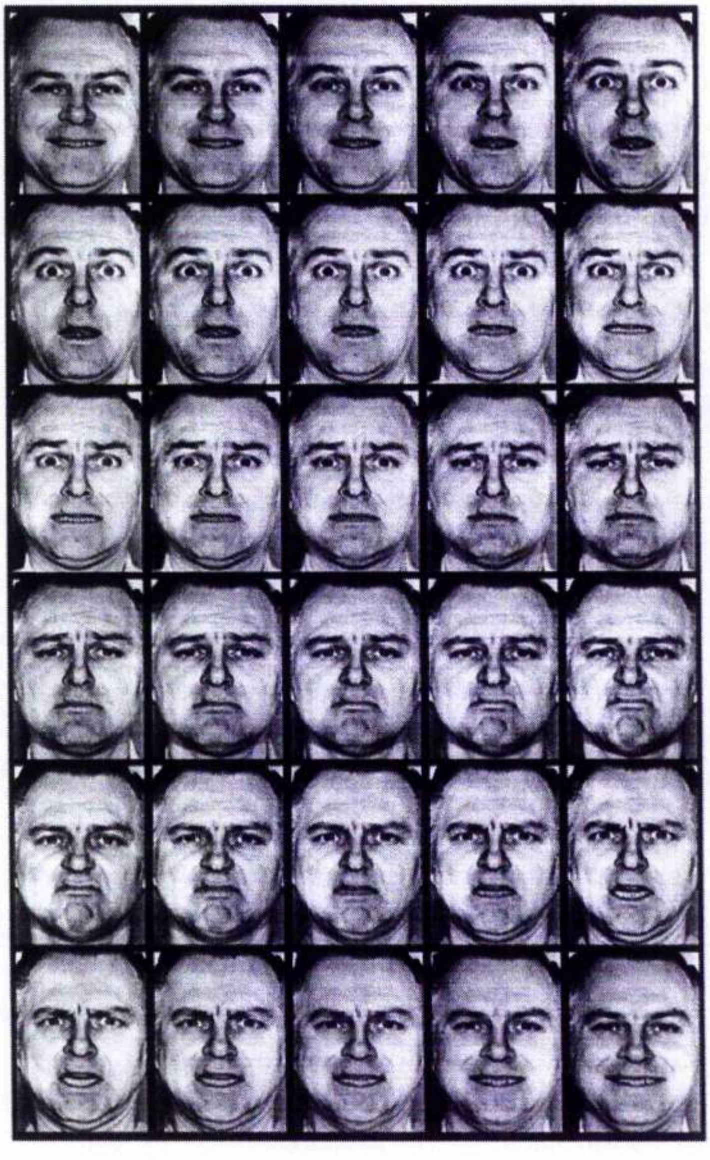


Figure 2.2: Faces used in the emotion hexagon task.

2.2.1b (ii) Procedure

In the Emotion Hexagon, the same computerised design as the Ekman 60 is employed. The participants undertake six blocks of trials. Each block includes all 30 morphed faces in a random order. The first block is a practice trial. The performance on this task is assessed by dividing the thirty faces into six categories – each category contains five faces which should be consistently labelled with one emotion from the six. The surprise section, for example, includes five faces, made up as follows: 100% surprised, 90% surprised-10% happy, 70% surprised-30% happy, 90% surprised-10% fear, 70% surprised-30% fear; and so on, for each emotion. The instructions are included in Appendix 2.

2.2.1c Ekman 50

A third facial emotion task was employed in a few studies in this thesis. This task included the same stimuli and followed the same procedure as the Ekman 60. The ten photographs of actors posing surprise were excluded from this study, as well as surprise as a response choice.

2.2.2 Vocal tests

2.2.2a Nonsense vocal emotion stimuli

2.2.2a (i) Stimuli

This task was developed by Sprengelmeyer and colleagues (1996) for use in neuropsychological research. In this test, the same German actor vocalised 10 nonsense phrases (made up from meaningless words), using different emotional intonations (representing anger, disgust, fear, happiness, sadness, and surprise). Vocal prosodic cues were varied.

2.2.2a (ii) Procedure

Participants listened to the audio track, which was played through a computer and they had to indicate which emotion from the list of six emotions was expressed in the phrase that they heard. Participants had their responses recorded by the experimenter. The next phrase or expression was not presented until the participant had made their decision regarding the previous stimulus.

2.2.2b Verbal vocal emotion stimuli

2.2.2b (i) Stimuli

The second vocal test was developed by Calder and colleagues (2000) for use in neuropsychological research. In this test, a series of numbers (e.g. 'five, seven, two, three, nine') were spoken aloud in different emotional tones. This test was also designed to vary prosodic cues while keeping semantic cues constant. Ten different actors conveyed the ten phrases within each emotion condition. The proportion of male and female actors was similar for each emotion category. Each emotion was represented ten times and the five basic emotions, anger, disgust, fear, happiness, and sadness (this excludes surprise) were represented.

2.2.2b (ii) Procedure

The procedure for this test was similar to the previous vocal task. Again, participants had to indicate which emotion they thought was represented by the vocalisation. Participants taking part in the age study (Chapter 8) or the clinical participants (Chapter 9) had their responses recorded by the experimenter, all other participants indicated their own responses by pressing appropriate buttons on the computer. If participants needed to hear the phrase again, it was replayed.

2.2.3 Gestural cue tests

2.2.3a Stimuli

This set of stimuli enabled the examination of emotion recognition when expressed gesturally without facial or vocal cues. A series of digital video clips showed actors expressing five emotions (anger, disgust, fear, happiness, and sadness) in two lighting conditions (Atkinson, Dittrich, Gemmell, & Young, 2004). The stimuli consisted of ten displays of every emotion in each condition. The same actors did not always represent each emotion. For anger, there were five males and five females acting these body movements. For happiness, there were four males and six females. For fear, there were three males and seven females. For sadness, there were five males and five females. And for disgust, there were six males and four females. The two different conditions are described below.

These stimuli were digital video recordings of moving figures. Each clip was 4-8 seconds long. The actors were filmed against a dark background. Actors wore a body suit was made from dark-grey, tight-fitting material, and dark-grey tights were placed over their heads, so that facial cues are not available to the observers. Head movements and orientation could still be seen though. A specialised camera recorded the expressions, so that they could be presented as stimuli in full-light conditions and in point-light conditions. Full-light conditions refer to normal lighting but black and white transmission of the clips. There were thirteen 20mm-wide reflective strips placed at various points on the body suit worn by the actors. These reflective strips were placed on each ankle, each knee, each elbow, each hand, each hip and each shoulder, and one on the forehead. The strips completely encircled each limb. In the point-light conditions, only these strips are visible against a black background. The strips are sufficient to give the impression of biological movement, without providing cues from form and shape.

In each clip the actor starts in a neutral position, with his/her arms by their side, 5.5m from the camera and directly in line with it, and then the actor acts out the emotion and returns to the starting position. The five emotions portrayed were anger, disgust, fear, happiness, and sadness. From the one hundred clips, fifty show the expressions in full-light conditions and 50 show the same movements in point-light conditions. These two types of clips were digitally edited and produced from identical footage using Apple Computer's Final Cut Pro 2.0 and Pinnacle Systems' Commotion Pro 4.0 DV editing software packages. Figure 2.3 is an example of a full-light movie reel, and Figure 2.4 is example of the corresponding point-light movie reel.

The original movies were created in QuickTime movie files. The clips were converted from .mov format to .avi format using RAD Video Tools (Roberts, Engelberg, Miles, & Powell, 2002), and then compressed (the size of the movie was too large to run smoothly otherwise). The movies were also cropped slightly using Fast Movie Processor (Tibljas & Nikolic, 1999). The movies were then programmed to run automatically using Visual Basic.

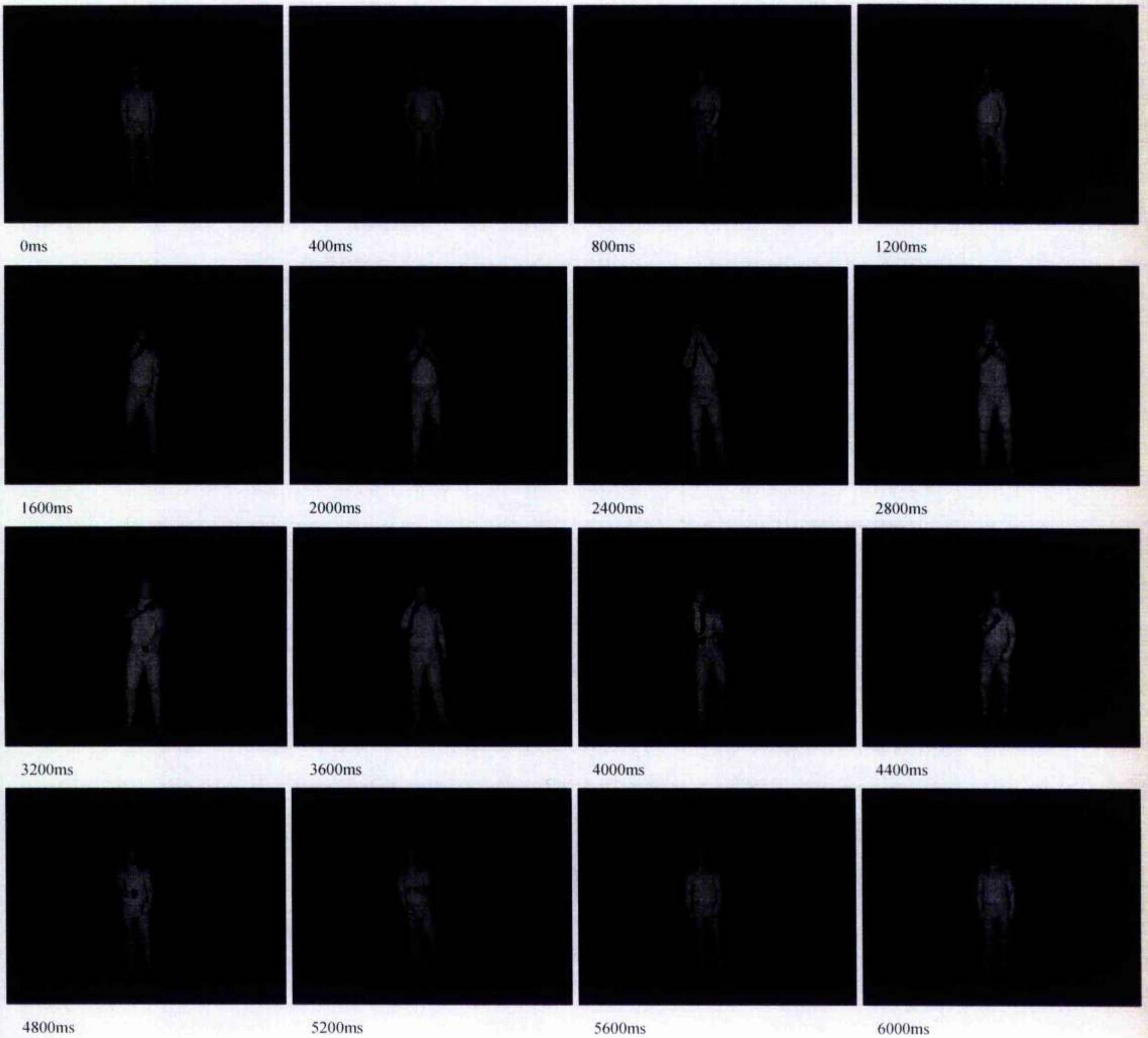


Figure 2.3: A reel showing frames from a dynamic full-light gestural portrayal of anger.
This clip is 6 seconds long. The frames shown above represent the point of movement every 400ms.

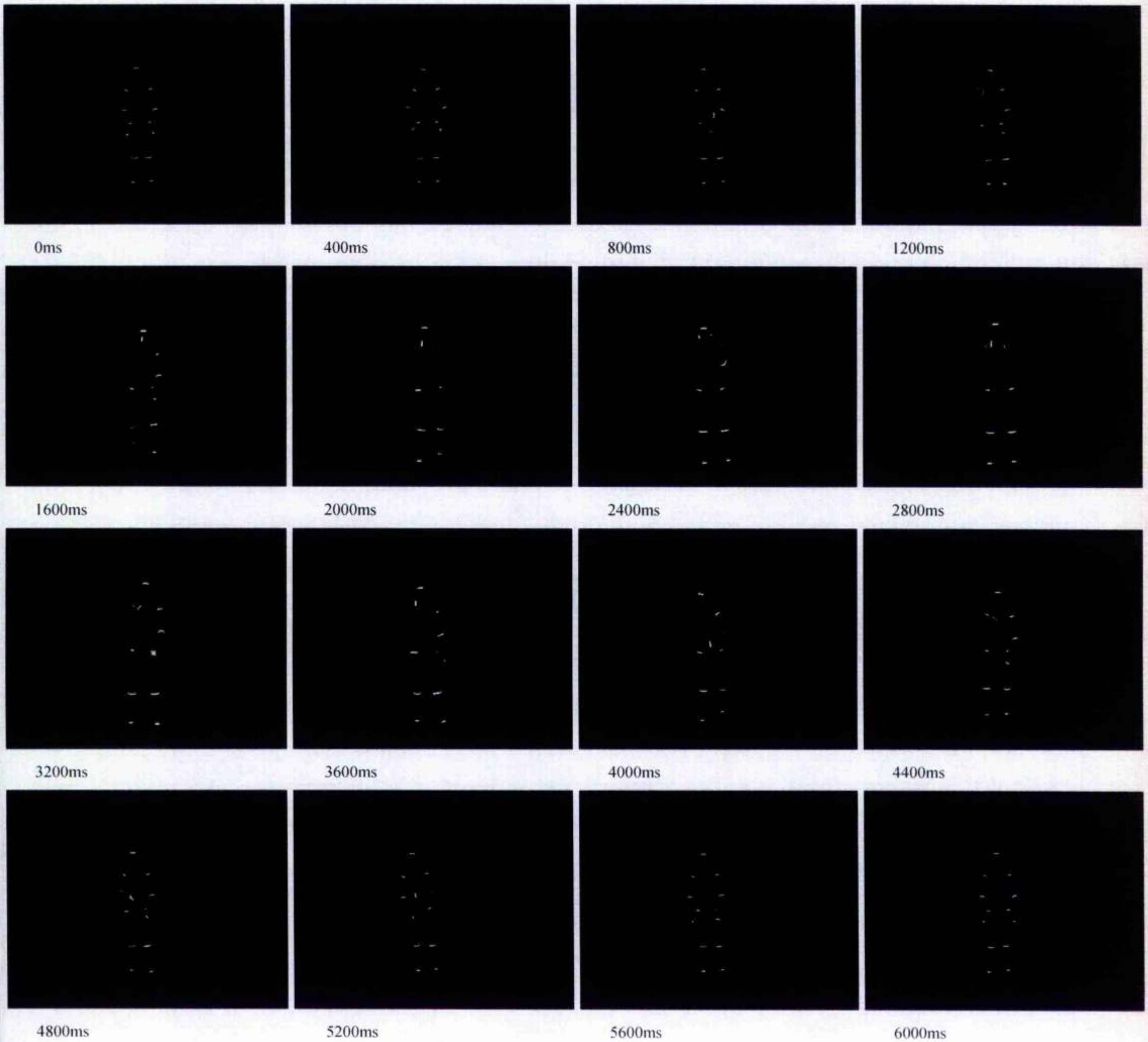


Figure 2.4: A reel showing frames from a dynamic point-light gestural portrayal of anger. This clip is 6 seconds long. The frames shown above represent the point of movement every 400ms.

Summary

To reiterate: for each of the fifty selected gestures, footage was used to develop a full-light movie and corresponding movie in point-light conditions. For further information regarding these stimuli, please refer to Atkinson and colleagues (2004).

2.2.3b Design

The full-light movie and point-light movie conditions were presented in two separate blocks of trials, in a repeated measures design. The order of presentation was counterbalanced across participants.

2.2.3c Procedure

2.2.3c (i) Group presentation format

The clips were displayed on a projector screen connected to a Dell Inspiron 1100 laptop. All stimuli were presented in the centre of the screen, with each figure appearing roughly 1.5m in height. Participants were seated in front of the projection screen. All participants were seated far enough back from the screen so that the entire screen was in the centre of their visual field. Instructions were presented to participants on the computer screen to read at their own pace, and they were also read out by the experimenter (see Appendix 2). Participants were told that they would be shown a series of short movie clips showing actors portraying emotions using their body and their task was to indicate which emotion they think was expressed by that actor. They were then shown an example of the type of stimuli used in that condition. The participants chose from a list of the five emotions, which was permanently on display on the screen. Participants marked their choice on a response sheet. The trial number was also visible on the screen. When the participant had made their choice, the experimenter presented the next video clip. No feedback was given concerning the correctness of any responses.

2.2.3c (ii) Single participant presentation format

The clips were displayed on a 15.0 inch Toshiba Satellite 2410 laptop. All stimuli were presented in the centre of the screen. The figures were around 3 inches in height. Each participant was seated directly in front of the computer screen. The same instructions were presented as in the group format. Participants told the experimenter their choice and this was recorded. Single participant presentation format was used in studies described in Chapters 8, 9, and 10.

2.3 Statistical analysis

For most tasks in each study, data were submitted to mixed-design ANOVAs. The between-subjects factor was group/task, and the within-subjects factor was recognition accuracy for each emotion (anger, disgust, fear, happiness, sadness, and surprise if included in the task). Greenhouse-Geisser corrections were administered where possible. If a significant or borderline interaction or group/task difference was revealed, then the analysis was generally followed by independent t-tests, equal variances assumed where appropriate, in order to explore impairments in specific emotions. In some cases, performance for individual emotions was contrasted between groups when the emotion by group interaction was non-significant. This was because (a) interactions are less likely to be significant when one factor has many levels, and (b) since this thesis is concerned with recognition of *specific* emotions, rather than emotion recognition in general. Such analysis methods are precedent in the literature (Jacobs, Shuren, Bowers, & Heilman, 1995; Phillips, MacLean, & Allen, 2002; Sprengelmeyer, Young, Pundt et al., 1997).

2.4 Discussion

Descriptions of the stimuli employed in this thesis are included above. References to this chapter will be made throughout the thesis, when each of the stimuli has been employed.

3 MOOD EFFECTS ON GESTURAL EMOTION RECOGNITION

Recent research has shown that clinically-defined mood disorders can affect recognition of emotion exhibited by others. As a consequence, this chapter addresses the impact of mood traits on emotion perception in a normal population. Interpretation of emotions that are communicated by body movements will be explored in this study.

3.1 Introduction

3.1.1 General background

Emotions are fundamental to human behaviour. The ability to interpret cues from counterparts' faces, voices, and gestures in order to discern which emotion they are feeling is integral to social communication and interaction. This facilitates our predictions of the intentions and emotional states of others, thus influencing and, consequently, guiding our own behaviour. It is not clear how our own internal states may influence our interpretation of emotional cues, however. Recent research has shown that clinically-diagnosed mood disorders, can affect recognition of emotion, yet there has been little research investigating whether less permanent psychological states or traits in a normal population may have an impact on the ability to construe emotions of others. Moods represent individual differences, and it would seem plausible that a person's own mood state or trait may in turn bias their understanding of social and emotional environments.

3.1.2 Mood effects on perception

According to the Diagnostic and Statistical Manual of mental disorders IV (APA, 1994), moods are a pervasive and sustained 'emotional climate', whereas affect reflects more fluctuating changes in 'emotional weather'. Mood traits reflect the tendency to experience a particular mood state.

Moods seem to have the ability to influence reasoning, judgements, and decisions. Forgas (2000) suggested that moods may not only affect *what* humans think in terms of cognitive content, but also *how* we think; that is, our cognitive processes may be influenced.

For instance, moods appear to evoke more mood-salient thoughts but can reduce task relevant thoughts (Seibert & Ellis, 1991). Moods have been reported to impede performance on memory, executive functioning, reasoning, and motivation tasks (Bodenhausen, Kramer, & Süsser, 1994; Oaksford, Morris, Grainger, & Williams, 1996; Phillips, Bull, Adams, & Fraser, 2002). By contrast, Isen (1999) observed that positive moods can elicit more associations to targets words, which could, in turn, enable participants to interpret situations or stimuli more thoroughly.

3.1.2a Induced mood

Influences of mood on perception of emotions are often mood-congruent. Mood-congruence refers to an increased accuracy of perception or faster responses in interpreting emotional stimuli that are comparable with the mood being experienced, such as a person in a happy mood being faster or better at responding to positive stimuli. Mood-congruent effects on affectively loaded words are exhibited following mood induction, using musical techniques (Niedenthal, Halberstadt, & Setterland, 1997; Niedenthal & Setterland, 1994). In other words, when a person listens to music that stimulates a positive mood, then they are faster to respond to words associated with happiness. A similar outcome was demonstrated for sad moods and sad-related words. This finding did not extend to affective words that were unrelated to the happiness-sadness dimension, however. Another study provides further evidence for faster reaction times to mood-congruent lexical stimuli than to incongruent stimuli (Olafson & Ferraro, 2001).

Mood induction also influences facial expression perception (Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000). Participants had to alter a face using a computerised scale until it was perceived as being emotionally neutral. Emotionally congruent expressions were perceived to persist longer than those that were incongruent with the experienced mood, such that the when non-happy participants perceived the face as neutral, happy participants were still classifying it as happy. Thus, mood states enhance sensitivity to emotion-congruent states in others.

3.1.2b Anxiety

Anxious people attend more to stimuli that are anxiety-eliciting or threat-related than any other stimuli (Mathews & Klug, 1993). For instance, highly anxious *non-clinical* participants show an attentional bias to briefly presented threatening facial expressions (Bradley, Mogg, Falla, & Hamilton, 1998; Bradley, Mogg, & Millar, 2000; Mogg & Bradley, 2002; Mogg, Millar, & Bradley, 2000). This bias is characterised by fast reaction times to probes following threatening faces, and increased direction of eye movement towards these stimuli. A heightened tendency to respond to negative stimuli is found in groups with high *trait* anxiety (Bradley et al., 1998; Eysenck, MacLeod, & Mathews, 1987) and those with high *state* anxiety (Mogg, Bradley, DeBono, & Painter, 1997). This bias for various forms of threat-related stimuli occurs regardless of stimulus duration (Mogg & Bradley, 2002; Mogg et al., 1997).

In summary, mood states and traits of non-clinical populations have some influence on the perception of emotional stimuli. This effect has been demonstrated for emotional words and faces.

3.1.3 Mood disorders and effects on emotion recognition

The idea that moods can influence perception of another's emotional state has been explored further by examining clinical groups, such as people with mood disorders. It is disputed whether effects of mood disorders on emotion perception are mood-congruent, incongruent, or simply universal. Most research concurs that mood disorders have some effect on emotion perception, except for a few research studies (Archer, Hay, & Young, 1992; Gessler, Cutting, Frith, & Weinman, 1989).

3.1.3a Depression

Depressed individuals are often reported as displaying dysfunctional interaction behaviours. It has been suggested that they may act inappropriately because they cannot use other peoples' emotional cues to guide appropriate responses and behaviour.

Depression might have an incongruent impact on emotion perception. For instance, a specific impairment in fear and anger facial emotion recognition was found in adolescents and children (Lenti, Giacobbe, & Pegna, 2000). A further difficulty in perceiving negative emotions has been reported by Ekman and his colleagues (1969, cited in Persad & Polivy, 1993), who found that depressed individuals were more likely to label sad faces as happy.

By contrast, Mandal and Battacharya (1985) revealed that depressed patients have an increased sensitivity to sad emotional expressions and a bias to use the label 'sad' for other emotions. In accordance with this, depressed individuals judge all emotional and neutral faces less positively than control participants (Levkovitz, Lamy, Ternochiano, Treves, & Fennig, 2003). In other words, a mildly happy face would be perceived as more neutral, and negative expressions would appear more negative than intended to the depressed patient. Furthermore, in comparison to healthy individuals, depressed participants are slower to respond to happy faces (Suslow, Junghanns, & Arolt, 2001). Rubinow and Post (1992) found that depressed participants were significantly impaired in recognising facial happiness *and* sadness, but not verbal affect.

Depressed patients are more likely to remember sad faces and have a greater tendency to forget the happy faces in comparison to neutral faces, according to research by Ridout and colleagues (2003). This was the opposite pattern to the control participants. Thus, there may be a mood-congruent bias for emotional memory.

Some studies have concluded that depressed participants demonstrate a general deficit in recognising facial expressions of emotion. In other words, impairment in recognising emotions is shown, but it is not specific to certain emotions; all emotions are affected universally. Indeed, Feinberg (1986) reported a general deficit in emotion perception by depressed participants. Moreover, Persad and Polivy (1993) drew similar conclusions by comparing clinically depressed psychiatric patients with non-depressed psychiatric patients. They also compared a non-clinical group of depressed students with non-depressed students. They found that both clinical and non-clinical depressed groups showed a generalised deficit in their perception of facial emotions in others. Despite this, there was no apparent pattern in terms of a specific emotion deficit.

Generally speaking, depression seems to be associated with an impairment in facial emotion recognition (Gur, Erwin, Zwil, Heimberg, & Kraemer, 1992). Nevertheless, it is yet to be established whether the processing of specific emotions may be impaired as a consequence of depression. Nor is it clear whether there is a depression-related deficit in other forms of emotion perception, such as vocal or gestural emotion recognition. In spite of this, the bulk of the research seems to be indicative of a mood-congruent effect of diagnosed depression.

3.1.3b Anxiety disorders

Perception of another's emotional state is affected in anxiety-related *clinical* disorders, including generalized anxiety disorder (Mogg, Bradley, & Williams, 1995; Mogg et al., 2000) and obsessive-compulsive disorder (Foa & McNally, 1986). These disorders have been associated with attentional biases to negative stimuli.

Both non-clinical groups with high levels of anxiety and patients with clinically-diagnosed anxiety disorders exhibit a bias towards interpreting ambiguous stimuli in a more threatening context than in the corresponding neutral context (Eysenck, Mogg, May, Richards, & Mathews, 1991; Eysenck et al., 1987; Mathews, Richards, & Eysenck, 1989). Mogg and collaborators (2000) revealed a bias in selective attention to threatening faces. Anxious participants directed their gaze more frequently and more quickly towards threatening faces than sad or happy faces, in comparison to control participants. Thus, the bias shown by patients suffering from anxiety disorders is not just related to word stimuli, but faces as well.

3.1.3c Summary

It has been observed that mood disorders have an impact on emotion perception, and indeed, more transient states, such as induced moods also have an influence. This emphasises that internal affective state plays a central role in our understanding and interpretation of our emotional environment.

3.1.4 Mood and dynamic gestural emotion

3.1.4a Aims

The purpose of this study is to explore whether emotion recognition varies in a systematic way in relation to the moods of a non-clinical population. Rather than using facial stimuli, however, or examining interpretation of ambiguous words, which are widely-used methods in established research circles, emotions conveyed by body movements will be employed. The relationship between moods and recognition of emotional body movements has not yet been explored.

3.1.4b Predictions

Research seems to indicate that negative moods increase sensitivity to negative stimuli. Consequently, it is predicted that negative moods will enhance sensitivity to negative body movements and positive moods will affect interpretation of positive body movements.

3.2 Method

3.2.1 Participants

From an original population sample of 248 students (75 males, 173 females) attending the University of St Andrews, three groups of 62 participants (186 in total) were selected to take part in this study as part of their practical classes.

These three groups were selected on the basis of their Positive and Negative Affectivity Schedule (PANAS) scores (Johnston, Wright, & Weinman, 1995), which is related to their trait affectivity – that is, their disposition to experience positive and negative moods. See Appendix 1 for the PANAS.

The control mood group had PANAS scores within the normal and average range for both the positive and negative affectivity scales. Their mean age was 18.92 years (s.d. 3.98). Eighteen were male. The positive mood group had high scores on the positive affectivity scale in relation to low scores on the negative affectivity scale. Their mean age was 19.15 (s.d. 2.60). Twenty-two were male. A negative mood group included participants with high negative affectivity in comparison to other participants. Their mean age was 18.82 (s.d. 1.60). Sixteen were male. These three groups did not differ in terms of age, $F_{(2, 185)} = 0.202$, $p>0.35$. Figure 3.1 shows the groups' positive and negative affectivity scores.

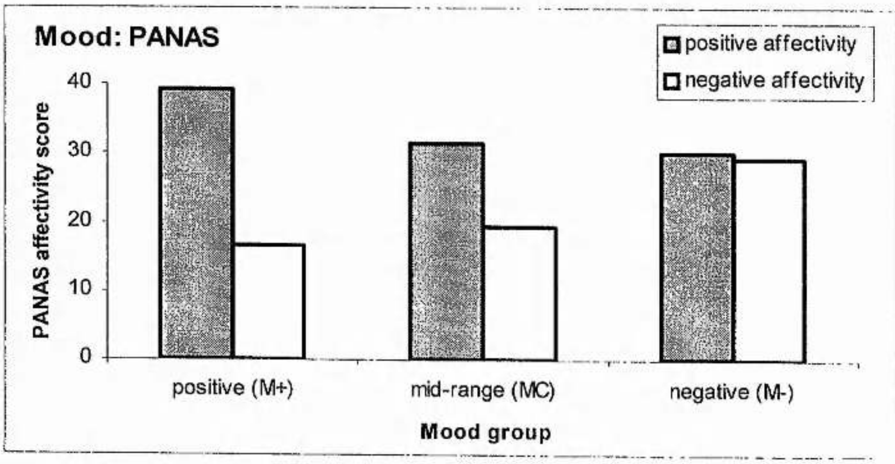


Figure 3.1: PANAS scores for the three different mood groups.

Positive affectivity scores for each group differed significantly, $F_{(2,185)} = 126.71$, $p<0.001$. Negative affectivity also differed significantly between groups, $F_{(2, 185)} = 238.29$, $p<0.001$. Games-Howell post-hoc tests (equal variances not assumed) revealed that the positive mood group had higher positive affectivity scores than the negative mood group ($p<0.05$) and the control group ($p<0.05$). The negative mood group had significantly higher negative affectivity scores in comparison to the positive mood group ($p<0.05$) and the control group ($p>0.05$).

While positive affectivity in the negative mood group is comparable to that of the control group, the contrast of their negative affectivity scores with those of other groups is more important in assessing moods, since clinically depressed participants also have this pattern in PANAS scores (Watson, Clark, & Tellegen, 1988).

3.2.2 Stimuli

3.2.2a Gestural emotion recognition tests

See Section 2.2.3 for a full description of the full-light and point-light movies used in this study.

3.2.3 Procedure

The gesture displays were given in group format, as participants were divided randomly into 6 groups for practical purposes. Each group was tested separately.

3.3 Results

3.3.1 Full-light gestures

The mean emotion recognition rates for these three groups of participants for the full-light gestures are shown in Figure 3.2.

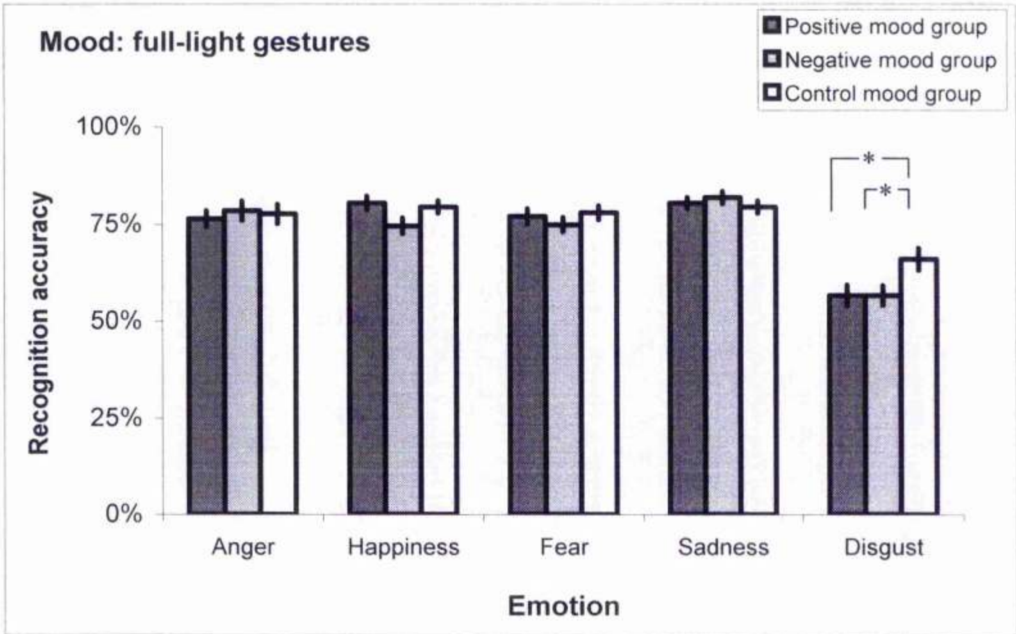


Figure 3.2: Recognition accuracy rates for full-light emotional gestures by participants with positive and negative moods and the control group.
The bars represent standard error. * $p<0.05$

A 3x5 mixed design ANOVA (between-subjects factor: mood group - positive, negative, and control; within-subjects factor: emotion - anger, disgust, fear, happiness, sadness accuracy rates) revealed a main effect of emotion, $F_{(4,732)} = 59.44$, $p<0.001$. This means that the relative ease of recognition differs per emotion. This was qualified by a significant group by emotion interaction $F_{(8,732)} = 2.36$, $p<0.05$. Groups differ in the recognition of particular emotions. The effect of group was not significant, $F_{(2,183)} = 1.24$, $p=0.291$. This means that overall, the three groups do not differ in their recognition of emotions.

Variance was not significantly different between emotions (as calculated by Levene's Test for Equality of Variance), thus Tukeys HSD test was used to explore the interaction. The control group differed significantly from both the positive and negative mood groups in their recognition accuracy rates for disgust ($p<0.05$ for each comparison). There was a trend for significance in differences between the positive and negative mood groups for the recognition of happiness ($p=0.058$). No other emotion recognition accuracy rates differed, $p>0.40$.

3.3.2 Point-light gestures

The raw scores for recognition accuracy of the point-light gestures are shown in Figure 3.3.

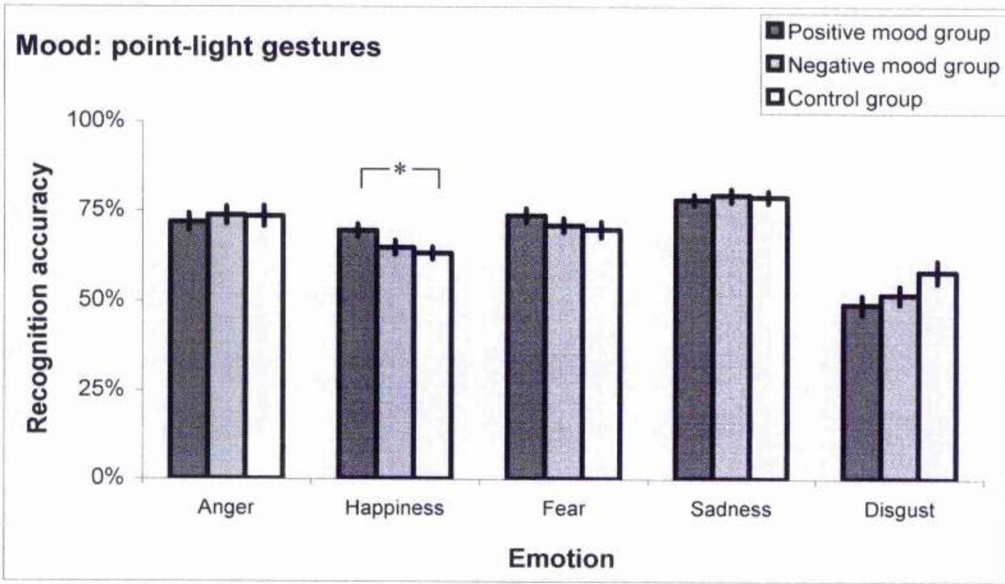


Figure 3.3: Recognition accuracy rates for point-light emotional gestures by participants with positive and negative moods, and the control group.
The bars represent standard error. * $p<0.05$

A 5x3 mixed-design ANOVA revealed that there is a significant main effect of point-light emotion, $F_{(4,732)} = 67.49$, $p<0.001$. This is supported by a significant group by point-light emotion interaction, $F_{(8,732)} = 2.22$, $p<0.05$. There is not a significant group difference overall, however, $F_{(2,183)} = 0.05$, $p=0.95$.

Equal variance can be assumed for the different groups and their point-light movie recognition rates ($p>0.05$). Thus, Tukeys HSD was used to explore the interaction. No differences between the positive mood group and the negative group can be reported ($p>0.05$). The control group differed significantly from the positive mood group for happiness recognition ($p<0.05$).

3.3.3 Confusion error analysis

To understand what processes may underlie the behavioural response differences by the two mood groups, confusion matrices were created to explore where each group made errors. Tables 3.1-3.3 show the pattern of responses by each mood group in the full-light gesture task - correct and mistaken responses are included. The data are presented as percentages.

Table 3.1: Confusion matrix for the positive mood group for their responses to full-light gestures.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived by the positive mood group	**Anger**	**76.3**	1.6	6.3	13.7	1.3	99.2	22.9
	Disgust	9.2	**56.6**	10.7	4.2	4.5	85.2	28.6
	Fear	4.7	9.0	**76.9**	0.5	12.4	103.5	26.6
	Happiness	7.4	7.9	1.6	**80.3**	1.5	98.7	18.4
	Sadness	2.4	24.9	4.5	1.3	**80.3**	113.4	33.1
Total depictions		100	100	100	100	100		
Incorrect labels (misses)		23.7	43.4	23.1	19.7	19.7		

Table 3.2: Confusion matrix for the negative mood group for their responses to full-light gestures.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived by the negative mood group	**Anger**	**78.4**	1.7	4.2	18.2	1.1	103.6	25.2
	Disgust	8.4	**56.6**	13.6	2.9	4.5	86.0	29.4
	Fear	5.6	9.9	**74.8**	1.6	11.0	102.9	28.1
	Happiness	6.6	6.4	2.4	**74.5**	1.6	91.5	17.0
	Sadness	1.0	25.4	5.0	2.8	**81.8**	116.0	34.2
Total depictions		100	100	100	100	100		
Incorrect labels (misses)		21.6	43.4	25.2	25.5	18.2		

Table 3.3: Confusion matrix for the mood control group for their responses to full-light gestures.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived by the control mood group	**Anger**	**77.5**	2.8	6.1	15.9	1.2	103.5	26.0
	Disgust	8.4	**65.9**	11.6	2.6	4.9	93.4	27.5
	Fear	4.9	7.5	**77.9**	0.8	12.5	103.6	25.7
	Happiness	8.0	4.1	1.5	**79.4**	2.1	95.1	15.7
	Sadness	1.2	19.7	2.9	1.3	**79.3**	104.4	25.1
Total depictions		100	100	100	100	100		
Incorrect labels (misses)		22.5	34.1	22.1	20.6	20.7		

Responses when disgust and happiness were represented were compared, a mixed design ANOVAs did not reveal any significant differences between the groups in their mistaken responses (misses) when other emotions were depicted, $p>0.1$.

A 3x4 mixed-design ANOVA with Greenhouse-Geisser corrections investigated the emotions that each of the groups confused with disgust. The between-subjects factor was group (positive, negative, control). The within subjects factor was emotion (the percentage of incorrect responses for each non-disgust emotional label when disgust stimuli were presented). The ANOVA compared responses of the three mood groups, in terms of the number of times anger, fear, happiness, and sadness are incorrectly used when disgust is depicted.

The analysis revealed that there was a main effect of emotion, $F_{(1.94.\ 353.51)} = 119.93$, $p<0.001$. The interaction between groups and incorrect emotional responses was not significant, $F_{(3.89,\ 353.51)} = 1.29$, $p=0.270$. The between-groups comparison was significant, $F_{(2,183)} = 3.67$, $p<0.05$. This reflects differences between the groups in their accuracy rates for disgust, reported earlier. Due to the number of levels per factor, and the interest in specific emotions, independent-samples t-tests were carried out (see Section 2.3). These indicated that the negative mood group showed a trend to describe disgust clips as 'sadness' (mean = 25.4%) more than the control group (mean = 19.7%), $t(121) = 1.87$, $p=0.064$. The positive mood group tended to be more likely to label disgusted gestures as 'happiness' (mean = 7.9%), in comparison to control participants (mean = 4.1%): $t(108.28) = 1.96$, $p=0.053$. For all other comparisons, $p>0.08$.

The labelling of happiness clips was explored in the same way. A significant effect of emotion was revealed, $F_{(1.80,\ 328.23)}$ = 179.74, p<0.001. The emotion by group interaction was not significant, $F_{(3.61,\ 328.23)}$ = 1.84, p=0.128. A borderline group difference can be reported, perhaps driven by the larger number of misses for the negative group, $F_{(2,183)}$ = 1.84, p=0.066. The negative mood group was more likely than the positive mood group to label happiness representations as 'anger' (positive mood group mean = 13.7%, negative mood group mean = 18.2%), $t(122)$ = -2.02, p<0.05. For all other comparison, p>0.08.

Overall, the groups did not differ in their frequency of incorrect label usage for any one emotion (false positives), as assessed by a 3x5 mixed-design ANOVA (between-subjects factor = group, within-subjects factor = total false positives for each emotion). There was a main effect of emotion, $F_{(3.41,\ 620.17)}$ = 53.42, p<0.001. This may have been driven by the tendency of all groups to use the label 'happiness' less erroneously than other emotions. The group by emotion interaction was not significant, $F_{(6.82,620.17)}$ = 0.35, p=0.928. There was no main effect of group, $F_{(2,183)}$ = 0.41, p=0.668.

In summary, the negative mood group had a propensity to describe disgusted gestures as resembling 'sadness'. The positive mood group was more likely to label disgusted gestures as 'happiness' than the control group. By contrast, the negative mood group was more inclined than the positive mood group to label happy gestures as 'angry'.

Confusion analysis for the point-light task was not performed as few significant differences were revealed between mood groups in their recognition rates on this task.

3.4 Discussion

Past research has shown that diagnosed mood disorders influence interpretation of emotional stimuli. In the present study, body movements conveying emotions were used to explore whether moods of a non-clinical population affect emotion recognition. Unexpectedly, negative and positive mood *traits* produced difficulties in disgust perception.

3.4.1 Mood congruent findings

It was initially hypothesised that individuals with a negative disposition would be more likely to recognise the negative emotions from body movements, such as sadness or anger, than those with a positive disposition. The results indicate that people with positive mood dispositions tend to be more accurate at perceiving happiness than the negative mood group. They are also more likely to label disgust clips as happiness than the control group. Negative mood congruence seems to have a more covert effect on processing, since the negative mood group was more likely than the control group to describe the disgusted gestures as similar to sadness. Further mood-congruence was demonstrated, since the negative mood group tended to perceive happiness as resembling anger more than the positive mood group.

The PANAS provides a rare opportunity to measure positive trait affectivity. This could explain the presence of the current positive mood-congruence finding. Most mood scales only offer the prospect for measuring negative affect or something comparable. It is important to note that 'negative affectivity' is not a direct measure of sadness, but negative mood, which seems to be a combination of two lower-order factors, which represent 'being upset' and 'being afraid' (Killgore, 2000a). Consequently, negative affectivity essentially encompasses depressed mood *and* anxious mood. Therefore, given that happiness is more directly congruent with a positive emotional state than a specific negative emotion with a general negative emotional state, this may render happy expressions more amenable to influences on perception.

Another factor in explaining the present pattern of results in overall sensitivity levels may be related to motivation. Schwartz and colleagues (1991) argue that processing happiness may require less effort for participants in positive moods, since it is related to their own internal disposition, whereas participants with predominantly negative moods have more motivation to attend to the specifics of a task or situation and are adaptive in addressing problems. Therefore, people with negative moods are more likely to spontaneously engage in systematic processing (Bodenhausen et al., 1994; Park & Banaji, 2000).

3.4.2 Disgust perception

The control group were more accurate than both the positive and negative mood groups in the perception of disgusted body movements, and this was observed in both presentation conditions.

Generally, recognition of disgust from dynamic gestures is more difficult for all participants, regardless of their mood. This suggests that these stimuli are less distinct than other emotions represented by gestures. Indeed, De Meijer (1989) and Heberlein and colleagues (in press) suggest that gestural representations of disgust cannot be associated with any easily identifiable, *natural* body movement. Perhaps this general uncertainty in interpretation renders the disgust stimuli in the current study more susceptible than other gestures to the impact of moods.

The present results may be related to sampling, however. For instance, obsessive-compulsive disorder (OCD) and eating disorders have a high incidence within young populations in western societies (Gordon, 1990; Hoek & Van Hoeken, 2003), and this may be the case in the population investigated in this study. The sample had a female majority as well. OCD, eating disorders, and the female sex are all associated with high disgust sensitivity (Davey, Buckland, Tantow, & Dallos, 1998; Druschel & Sherman, 1999; Haidt, McCauley, & Rozin, 1994; Mancini, Gragnani, & D'Olimpio, 2001; Quigley, Sherman, & Sherman, 1997; Sprengelmeyer, in preparation; Thorpe, Patel, & Simonds, 2003). Indeed, OCD and eating disorders have similar symptoms and phenomenology (Thiel, Broocks, Ohlmeier, Jacoby, & Schüßler, 1995). Cases with elevated disgust sensitivity have been linked to disturbed disgust perception (Sprengelmeyer, Young, Pundt et al., 1997). This is indicative that difficulties in perceiving disgust may be related to disturbed sensitivity to disgusting stimuli.

3.4.3 Methodological critique

The independence of the two subscales – positive and negative affectivity – and the validity of the PANAS has been confirmed by Watson and colleagues (1988). It might be advantageous to use two or more different mood assessment tools, however, to be confident that the results reflect specific moods.

In addition, the use of the gestural emotion task should be accompanied by a degree of caution, since it might be a relatively blunt instrument for assessing subtle differences in emotion perception abilities. Perhaps a more sensitive tool is required.

3.4.4 Conclusions

To fully understand the impact of moods on the interpretation of emotional stimuli, a more comprehensive range of tests should be applied, such as exploration of facial or vocal emotion perception. More transient moods could be examined, or different mood assessment methods could be employed, if extending this research.

Extrapolative inferences from this study within a clinical context are limited, since it is not known to what extent positive and negative affect might be related to clinical populations, such as those with depression or suffering from mania. Mood disposition does not necessarily equate with mood disorder. Additional research could examine the application of these findings in a wider context.

Until this work can be extended, however, it is apparent that mood traits, as measured by the Positive and Negative Affect Schedule, do have an impact on the recognition of dynamic emotional gestures, particularly happiness and disgust. This impact is manifested not simply in absolute sensitivity levels, but in mis-labelling as well.

4 MOOD EFFECTS ON VOCAL EMOTION RECOGNITION

Based on the results observed in the preceding study (see Chapter 3) and previous research (see Section 3.1), it is plausible that moods have an influence on emotion processing. The aim of this next experiment is to administer a measure of mood state, rather than trait, and a vocal emotion recognition test, to examine whether conclusions from the previous chapter can be generalised and applied to other populations.

4.1 Introduction

The previous study stresses the modulatory role that moods appear to play in the processing of emotions displayed by others. Previous literature and the preceding study have indicated that mood-congruent influences seem to occur in emotion perception. These effects are shown in recognition accuracy levels and frequency of use of particular emotional labels. The former experiment also revealed an unexpected relationship between mood and the responses concerning disgust stimuli. Consequently, a second study has been designed to explore whether such findings are generalisable.

Past research has established that mood influences the processing of facial expressions of emotion (Bradley et al., 1998; Bradley et al., 2000; Bradley et al., 1997; Killgore & Cupp, 2002; Mogg & Bradley, 2002; Mogg et al., 2000; Niedenthal et al., 2000). The preceding study bolstered this finding using gestural representations of emotion. Vocal representations of emotion do not appear to have been examined in a mood related context. Several researchers consider vocal expressions to be a fundamental method for conveying emotion. Consequently, in this experiment, perception of vocal emotion and its relationship to mood was investigated.

As mentioned in the previous chapter, negative affectivity, as measured by the PANAS, is actually a combination of two factors that may represent depressed mood and anxious mood (Killgore, 2000a). It is of interest to separate these factors and explore whether one may be more likely to modify emotion recognition abilities. The Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983) was therefore employed in the current study to distinguish effects of anxiety and depression. The HADS differs from the PANAS, in that rather than just measuring negative affectivity, it is divided into two subscales assessing anxiety and depression. The HADS also does not measure positive mood characteristics, so the focus of this study was more on negative mood characteristics and their influence on emotion perception. Since much established research has focused solely on negative moods/traits, for the purpose of this study, their exploration was deemed sufficient to reveal any affected pattern of behaviour that may have occurred. This measure has been used in countless clinical studies and in a number of investigations examining healthy populations too. This questionnaire was employed in the current study.

It was predicted that mood-congruent patterns of behaviour would be revealed. These might be displayed in the form of recognition bias or labelling bias.

4.2 Method

4.2.1 Participants

One hundred and thirty-seven students from the University of St Andrews participated in this experiment. The number of participants in this study was smaller than that of the previous study, so the population was divided into two groups. The HADS is a continuous scale, differentiating between normal, mild, moderate, and severe mood disorders. Please see Appendix 1 for the HADS. Since a relatively healthy, non-clinical population was explored in this study, high scores on the HADS were not expected. Consequently, rather than designating the groups on the basis of the pre-defined categories, they were allocated by dividing the whole sample into those with relatively high and low scores on the depression subscale, and relatively high and low scores on the anxiety subscale. There were 81 women and 56 men who participated in this study. Their age range was 18-24 years. The men had a mean age of 20.5 (s.d. 2.20). The women had a mean age of 20.1 (s.d. 1.49). The mean age of the male participants and the mean age of female participants do not differ significantly [$F_{(1,136)} = 2.26$, p=0.14].

The control dysphoria group had low HADS depression scores (0-3, mean 1.83). This group consisted of sixty-nine students, thirty-three of whom were male. The more dysphoric group had higher scores (≥4, mean 5.47). This group comprised sixty-eight students, including twenty-three males.

For a second analysis, participants were divided into anxiety groups. The control anxiety group had comparatively low anxiety scores (0-7, mean 5.77). Sixty-nine students were in this group and thirty-seven of these were male. The relatively anxious group had sixty-eight students with anxiety scores ≥8, mean 10.6. Nineteen of these students were male.

Figure 4.1 shows the mean depression and anxiety scores for the four groups.

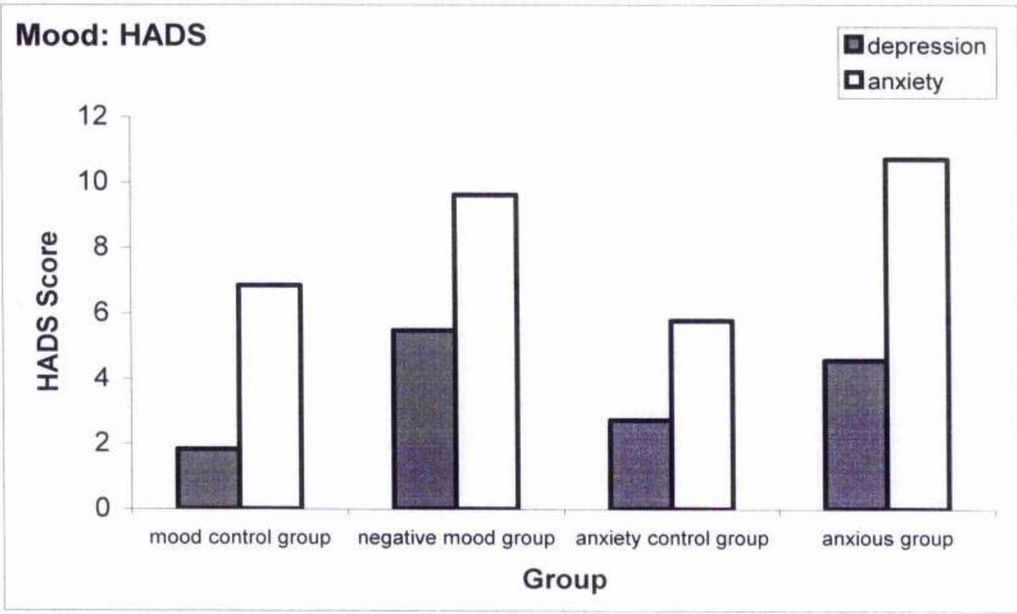


Figure 4.1: HADS scores per group.

Between-subjects ANOVA revealed that the more dysphoric group had higher depression scores [$F_{(1,136)}$ = 182.3, p<0.001] and anxiety scores [$F_{(1,136)}$ = 30.6, p<0.001] than the control dysphoria group. The relatively anxious group had higher anxiety scores [$F_{(1,136)}$ = 191.6, p<0.001] and higher depression scores [$F_{(1,136)}$ = 23.0, p<0.001] than the control anxiety group.

4.2.2 Stimuli and procedure

The computerised vocal emotion task (as described Section 2.2.2b) was given to the participants. This task was slightly modified due to time constraints: only eight vocalisations per emotion were presented, rather than ten. The eight were selected randomly. The participants listened to the sounds through headphones.

4.3 Results

4.3.1 Dysphoria groups (determined by depression scores)

The mean emotion recognition accuracy scores on the vocal emotion perception task for the two depression groups are shown in Figure 4.2.

A repeated-measures ANCOVA with Greenhouse-Geisser corrections was applied to the data to explore the differences in percentage accuracy of emotion recognition between the dysphoria groups, with anxiety scores entered as a covariate. There was no main effect of emotion portrayed on recognition accuracy, $F_{(3.69,494.39)}$ = 1.10, p=0.358. Nor was there an interaction between anxiety scores and recognition accuracy scores for each emotion, $F_{(3.69,494.39)}$ = 0.313, p=0.869. There was no main effect of dysphoria group, $F_{(1,134)}$ = 1.46, p=0.23; but the emotion by dysphoria interaction was significant, $F_{(3.69,494.39)}$ = 3.72, p<0.01. The relationship between dysphoria group and emotion perception was explored further using MANCOVA. A significant difference between the two groups in disgust perception was demonstrated, $F_{(1,134)} = 9.83$, $p<0.005$, but not for other emotions, all $p>0.28$.

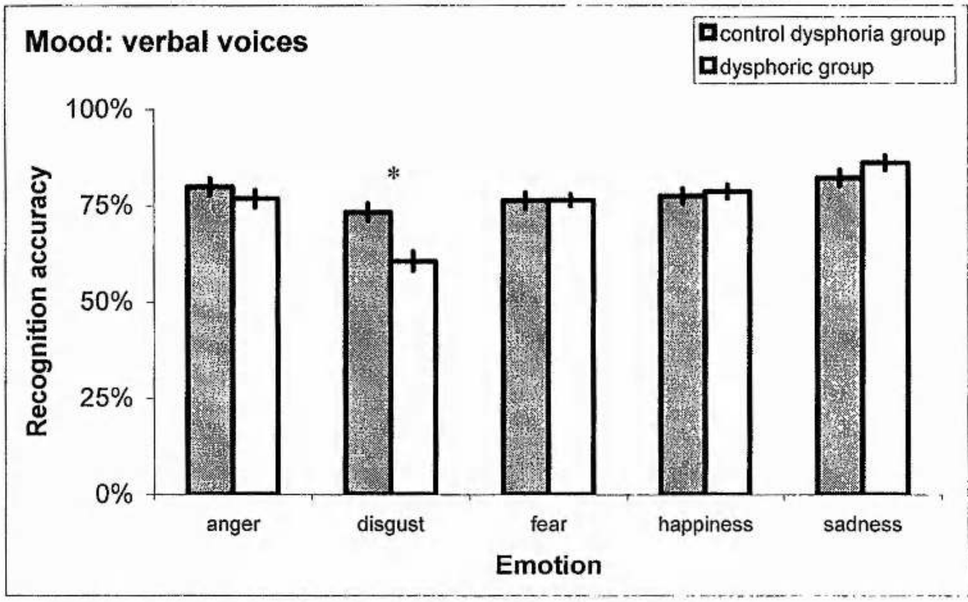


Figure 4.2: Recognition accuracy rates for the control dysphoria group and the dysphoria group. The bars represent standard error. * $p<0.005$

4.3.2 Anxiety groups (determined by anxiety scores)

An ANCOVA with Greenhouse-Geisser corrections examined the differences in accuracy of emotion perception between anxiety groups, with depression scores entered as a covariate. This revealed that there was no main effect of emotion represented in accuracy scores, $F_{(3.68,493.82)} = 0.96$, p=0.43. The anxiety by emotion interaction was not significant, $F_{(3.68,493.82)} = 0.06$, p=0.99. The difference between the anxiety groups bordered significance, $F_{(1,134)} = 3.71$, p=0.056. The relatively anxious group were marginally worse than the control group in their perception of vocal emotion. There was a significant interaction between depression scores and emotion, $F_{(3.69,493.82)} = 4.03$, $p<0.005$. Multivariate analysis using anxiety level as a between-subjects factor, and covarying depression raw scores, revealed no differences between anxiety and control groups for any specific emotion, all $p>0.22$.

4.3.3 Confusion analysis for dysphoria groups

Tables 4.1 and 4.2 give the pattern responses for the control dysphoria group and the dysphoric mood group respectively. These data are presented as percentages. Analysis explored for differences between the two groups in their incorrect label usage for each emotion category and false positive use.

Table 4.1: Confusion matrix for the control dysphoria group.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived by the control dysphoria group	**Anger**	**77.8**	9.9	2.8	4.3	1.5	96.3	18.5
	Disgust	16.1	**72.0**	3.3	6.6	9.6	107.6	35.6
	Fear	1.6	3.8	**75.7**	8.6	3.1	92.8	17.1
	Happiness	3.3	5.9	3.9	**77.3**	0.8	91.2	13.9
	Sadness	1.2	8.4	14.3	3.3	**85.0**	112.2	27.2
Total depictions		100	100	100	100	100		
Incorrect labels (misses)		22.2	28.0	24.3	22.7	15.0		

Table 4.2: Confusion matrix for the dysphoric group.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived by the dysphoric group	**Anger**	**78.3**	11.5	1.0	4.1	1.4	96.3	18.0
	Disgust	14.4	**60.0**	2.0	5.9	7.4	89.7	29.7
	Fear	1.0	5.1	**76.6**	8.4	5.2	96.3	19.7
	Happiness	4.9	10.5	3.7	**78.9**	1.6	99.6	20.7
	Sadness	1.4	12.9	16.7	2.7	**84.4**	118.1	33.7
Total depictions		100	100	100	100	100		
Incorrect labels (misses)		21.7	40.0	23.4	21.1	15.6		

Since disgust was the emotion that was most problematic for the dysphoric group, the incorrect responses (misses) for this emotion were explored. There was a significant effect of emotion, $F_{(2.59, 349.90)} = 10.23$, $p<0.001$. There was no significant interaction between group and percentage of emotion responses, $F_{(2.59, 349.90)} = 0.93$, $p=0.428$. There was a significant group effect, which could reflect poorer performance for disgust perception in the dysphoric group, $F_{(1,135)} = 12.40$, $p<0.005$. Independent t-tests compared the two groups' mean number of incorrect responses to each emotion category when disgust was vocalised (see Section 2.3 for rationale). Disgust was more commonly perceived as 'sadness' and 'happiness' by the dysphoric group in comparison to control participants: sadness label, $t(-2.60) = 135$, $p<0.02$; happiness label, $t(-2.25) = 102.86$, $p<0.05$. There were no significant differences between the groups in their use of 'fear' and 'anger' labels for the disgusted voices, $p>0.3$.

The dysphoric group generally used the labels 'happiness' and 'sadness' falsely more than the control dysphoria group: happiness, $t(135) = -2.29$, $p<0.05$; sadness, $t(135) = -2.15$, $p<0.05$. This is likely to be related to their use of these labels for disgusted voices. The use of other emotion labels did not differ between the groups, all $p>0.1$.

Generally, the dysphoric group had a greater tendency than control participants to label disgusted voices as 'sadness' and 'happiness'. Thus, type of labelling responses, as well as recognition accuracy of vocal disgust differentiates the two dysphoria groups. The dysphoria group confuse disgust with slightly different emotions when it was represented the vocal channel, in comparison to the gestural channel (see Chapter 3). This could reflect a dissociation between the two channels in terms of the relationship between emotions communicated vocally or gesturally (please refer to Chapter 10 for further exploration of this dissociation).

4.4 Discussion

The results revealed that negative moods appear to have an effect on vocal emotion perception, regardless of participants' levels of anxiety. This finding was specific to disgust. It is indicated that the lower the mood of the individual, the worse they are at recognising disgust. This result was also paralleled in the previous study (Chapter 3), which used emotional gesture displays and a different mood measure.

Explaining such a pattern is difficult. Eating disorders and obsessive-compulsive behaviours are related to an elevated sensitivity to disgust and disgusting stimuli, as established by previous research (see Section 3.4.2). As reported in the preceding study, since young populations often experience such disorders, the results may be influenced by the inclusion of participants displaying such behaviours and syndromes. It is possible that these problems are related to disturbed disgust perception. Furthermore, since it was indicated earlier that women are more easily disgusted, disparities in disgust perception may have their bases in an imbalance in numbers of males and females in each group. Subsequent work will analyse the groups in terms of gender to explore whether this disgust finding can be explained (see Chapter 6).

A further point of interest is that disgust is also the hardest emotion to identify from the voice, as well as from gestures (see Chapter 3 and Chapter 10). It does not seem to have a distinct vocal profile (Banse & Scherer, 1996; Van Bezooijen et al., 1983). Consequently, it is possible that moods may interfere in the interpretation of ambiguous stimuli. Certainly, if the confusion matrices are considered, it appears that the people with dysphoric moods were more likely to use the labels 'happiness' and 'sadness' for disgust. Choosing these labels suggests that this group were responding arbitrarily to the disgusted voices. A consistent pattern of responding in one direction over another (i.e. persistently mislabelling the disgust voices as sadness) would be more indicative of an incorrect labelling strategy being employed by this group of individuals. This mis-labelling was not mood-congruent, which conflicts with the labelling patterns of the previous study.

It is particularly interesting that the anxiety subscale did not interact with any variables in terms of its effects on emotion perception. Previous research (Bradley et al., 1998; Bradley et al., 2000; Mogg & Bradley, 2002, in press; Mogg et al., 1997; Mogg et al., 2000) has established a relationship between anxiety and a bias in attending toward negative stimuli. This heightened attention was not reflected in recognition accuracy for the current group; perhaps this was because none of the 'anxious' individuals described in this study represented highly anxious people. All scores were within the normal-mild range. Future research using the vocal stimuli and either anxiety mood induction techniques, or with patients suffering from clinically diagnosed anxiety disorders could explore this further.

In summary, this and the former experiment (Chapter 3) have established that mood influences emotion perception in diverse ways. Interpretations of facial emotional displays are readily influenced by clinical moods. Here, such effects were found for vocal emotion representations in a non-clinical sample. Disgust processing was affected most notably, given that people in a dysphoric mood had difficulties in recognising its expression. As a consequence, monitoring participants' mood states and traits should be stipulated in standard neuropsychological assessments aiming to explore emotion processing. It is currently ignored to a great extent. Underestimating the impact of individual differences on emotion perception is a limitation in much neuropsychological research.

5 MOOD & EMOTION RECOGNITION – INTERIM DISCUSSION

5.1 Summary of findings

Past research has shown that diagnosed mood disorders influence interpretation of emotional stimuli. In Chapters 3 and 4, body movements conveying emotions and emotional vocalisations were used to explore whether moods of a non-clinical population affect emotion recognition. People with positive mood traits were marginally better at recognising gestural happiness than the negative mood trait group. Negative and positive mood *states* and *traits* produced deficits in disgust perception in two modalities.

The results in Chapter 3 provided evidence that groups of people with negative and positive dispositions had difficulties perceiving gestural disgust in comparison to those without specific mood tendencies. Chapter 4 revealed that dysphoric mood affected perception of disgust represented by the voice, regardless of the participant's level of anxiety. The more depressed the mood of the individual, the worse they were at recognising disgust.

5.2 Disgust recognition difficulties

Recognition accuracy for gestural *and* vocal disgust is generally much lower than for other emotions. Thus, the more ambiguous or difficult an emotion is to interpret, the greater the tendency for mood to affect recognition. Disgust is not associated with a distinct natural body gesture (De Meijer, 1989; Heberlein et al., in press) or a distinct vocal profile (Banse & Scherer, 1996; Scherer, 1986; Van Bezooijen et al., 1983), unlike other ostensible basic emotions. The gestures represented here are more symbolic than natural, perhaps since disgust might be best communicated via the face. Consequently, people with a particular mood disposition might have found disgust harder to classify, as they may have been more confused by ambiguous stimuli.

Interestingly, Murray (2000) carried out a series of studies exploring facial emotion perception in clinically and non-clinically depressed individuals, and she found that both depressed groups were less sensitive to disgusted facial expressions than control groups. Depressed mood was assessed using the Beck Depression Inventory (Beck & Steer, 1987), and the state scale of the State-Trait Anxiety Inventory (Spielberger, 1983). This result complements the present research. Together, these studies suggest that depressed moods can be associated with impairments in the processing of disgust expressed in multiple communication channels.

5.3 Disgust deficit in clinical research – a caveat

Given that the population analysed in Chapters 3 and 4 were mostly female, and they were a young, student population, in which OCD and eating disorders are typically prevalent (Gordon, 1990; Hoek & Van Hoeken, 2003), all of which are associated with high disgust sensitivity and perhaps, disturbed disgust perception, it is possible that the results obtained here could reflect sampling, and might not occur in other non-clinical populations sampled for negative moods.

A number of studies have highlighted disgust recognition impairments in clinical populations, such as Huntington's disease patients (Sprengelmeyer et al., 1996; Sprengelmeyer, Young, Sprengelmeyer et al., 1997; Wang et al., 2003), in Huntington's disease gene-carriers (Gray et al., 1997), in Obsessive-Compulsive populations (Sprengelmeyer, Young, Pundt et al., 1997), and in Parkinson's disease patients (Kan et al., 2002; Sprengelmeyer et al., 2003). Please see Section 1.5.2d for more information. Generally, the authors of these papers argue that disgust facial perception may be related to basal ganglia functioning, since these regions tend to be compromised in the disorders described above. While the current studies did not explore facial emotion perception, if disgust is processed by an independent neural substrate, the findings reported in Chapters 3 and 4 indicate that disturbances in disgust processing might be related to depressed mood. This is in keeping with some clinical studies. For instance, Kan and co-workers (2002) examined Parkinson's patients with very high depression scores. Seven of the participants were classed as depressed, five were borderline, and two were classed as normal. In Kan's study, Parkinson's patients were reported as having difficulties perceiving facial disgust in comparison to control participants. This might be attributed to their more depressed mood.

The mean Beck Depression Inventory (BDI) score for the unmedicated Parkinson's patients in Sprengelmeyer and colleagues' (2003) study was 13.6, out of 30. This score, according to Kendall and collaborators (1987), can be classed as dysphoric. Half of these patients were categorised as depressed (with a score of 17 or more). The medicated group had lower BDI scores, with a mean of 11.6. This is not significantly different, but the group with higher depression scores were distinctly worse at perceiving facial disgust.

None of the other Parkinson's or Huntington's disease studies, in which emotion perception has been explored, report measures of mood. Nevertheless, it should not be discounted that moods may be at the basis of difficulties in recognising disgust, especially as depression affects between one third and a half of patients suffering from Parkinson's disease (McDonald, Richard, & DeLong, 2003; Rojo et al., 2003), Huntington's disease (Crauford, Thompson, & Snowden, 2001), and Obsessive-Compulsive Disorder (Overbeek, Schruers, Vermettern, & Griez, 2002). Not all studies report the same pattern in impairment in Huntington's and Parkinson's disease (see Section 1.5.3d), and this may be attributed to variation in depression levels in these populations, since not all patients experience depression.

The above proposition is not in conflict with the idea that the basal ganglia and insula cortex are involved in disgust perception. For instance, depression has been associated with functional abnormalities in the anterior insula, and structural and functional abnormalities in the ventral striatum (Phillips, Drevets, Rauch, & Lane, 2003b). Moods and disgust perception abilities may reflect the extent of neural changes to basal ganglia and insula cortex occurring in illnesses, like Huntington's and Parkinson's disease. The present research suggests that neuropsychological studies take into account that moods may play a role in the disgust processing.

5.4 Positive mood group inclusion – a suggestion

Some mood-congruent findings, consistent with the literature, were discussed earlier. The negative mood group were more likely to interpret gestural portrayals of happiness as depictions of anger. They also perceived gestural disgust as resembling sadness. On the vocal task, the negative mood group used the label 'sadness' more than the control group. Individuals with different moods tested in these studies seem to exhibit differential responses to particular expressions, rather than being distinguished by their overall sensitivity to emotional expressions.

An implication of these studies is that participants' moods should be appraised in neuropsychological assessments aiming to explore emotion processing. Underestimating the impact of individual differences on emotion perception is a caveat for neuropsychological research to date. Moreover, the divergence of the positive and negative mood groups from the control group demonstrated in Experiment 1 could indicate a danger in comparing only negative moods with a generic control group. Where no effect is reported when comparing a negative mood group and a control group, this may be due to the inclusion of people with high positive affectivity in the control group. Thus, where possible, positive moods should also be measured in future research.

5.5 Conclusions

In summary, the two present experiments have established that moods influence emotion perception in various ways. It has previously been demonstrated that interpretations of facial emotional displays are readily influenced by moods. Here, both vocal and gestural emotional representations were affected by moods. Thus, it seems that perception of emotion across modalities and modes of display is susceptible to individual differences in moods. Disgust processing was most notably affected, insofar as people with high positive affectivity scores and people with high negative affectivity scores had difficulty in recognising its expression. Further research could explore the influence of *both* mood states and traits on different forms of emotion perception, to ensure that the patterns observed in the present studies are replicated using different mood measures.

Neuropsychological and psychiatric research into emotion processing often highlights impairment in recognition accuracy for particular emotions. It is noticeable that the pattern of errors could be as important and even diagnostic. Indeed, the present results show that people with dysphoric mood often mislabel the emotion of disgust as sadness, across two modalities. It is a moot point as to whether this represents a problem with the emotion of disgust or sadness.

To conclude, the present study reveals that emotion perception across multiple modalities is affected by mood, particularly dysphoric mood. Emotion perception changes may be specific to disgust recognition, which is consistently confused with sadness. Disgust may be a defining feature of a disgust deficit. This is a novel finding that has key implications for emotion research.

6 SEX DIFFERENCES & VOCAL EMOTION RECOGNITION

Social stereotypes indicate that men and women show disparities in a number of aspects of emotional functioning. There are widespread effects of sex on emotion processing; however, studies largely ignore the possible interaction between sex of recipient and sex of the person emitting the emotional expression. Hence, the purpose of this chapter is to investigate the influence of sex differences of perceiver and emitter, and any relationship between the two, in perception of vocal emotion.

6.1 Introduction

The notion that men and women may differ in terms of their abilities to perceive emotions is not a novel concept. Stereotypes across diverse and disparate cultures have long suggested that women are the more emotionally expressive and more emotionally aware sex (Eagly, 1994; Fischer & Manstead, 2000). Sex differences have been reported in a wide range of aspects relating to emotional functioning, from experiential to perceptive abilities. Such differences could result from biological differences between men and women. Alternatively, these differences could arise from social influences, which tend to advocate that men should be the stronger, more aggressive sex. It should be noted that male and female social interactions with others of the same or opposite sex differ in quantity and quality.

6.1.1 Rationale

There are various reasons for this exploration of sex effects on emotion perception. First, most neuropsychological researchers acknowledge that there is a possibility that sex may play a role in perceptive abilities, but they approach this idea by matching their participants by sex, or having the same number of males and females in groups that are the subject of comparative studies. Since emotion expression recognition tasks are widely used in neuropsychological assessments, it is crucial that any sex differences are established in order to further our understanding and interpretation of the data yielded by such tasks. As a consequence, this chapter aims to tackle this key concern. Most of the literature cited here has referred to the influence of sex on facial expression recognition. Moreover, few studies have explored the influence of sex on the decoding of *vocal* emotion specifically. Scherer and colleagues (2001) observed that women were marginally better than men at recognising vocal emotion. This topic is also of interest since Chapters 3, 4, and 5 raised the issue that sex differences may be manifest in the emotion perception results reported earlier. As a consequence, the influence of sex on *vocal* emotion recognition is examined in this chapter.

The first task of this chapter is to explore the results of the previous study in terms of sex differences of the participants. This is followed by an analysis in which sex of the actors who created the vocal stimuli is explored. Finally, a further investigation exploring whether sex of actor and sex of participant might inter-relate and influence emotion recognition will also be reported.

6.2 Sex of the observer: male versus female participants (participant-based exploration)

Much emotion recognition research bolsters the view that women are more sensitive to the display of emotion in others (Barrett, Lane, Sechrest, & Schwartz, 2000; Brody & Hall, 2000; Hall, 1978, 1984; Hall, Carter, & Horgan, 2000b; Hall & Matsumoto, 2004; Kirouac & Doré, 1985; Rahman, Wilson, & Abrahams, 2004; Rotter & Rotter, 1988; Sogon & Doi, 1986; Thayer & Johnsen, 2000). In these studies, women consistently outperformed men in their detection of nonverbal emotional cues, from the face, voice, and body – in terms of their speed and accuracy of response. The general findings of a female advantage for emotion processing occur regardless of sample size, age of the stimulus actor, age of participant, or stimulus duration.

As referred to earlier, there are two potential explanations for these findings. The first is a sociocognitive view that skills such as emotion processing are based on experiences. Thus, learning is particularly important. The second view is neuropsychological, which suggests that female brains may be equipped differently to males for decoding emotions.

In terms of the sociocognitive stance, women's enhanced ability in perceiving emotions may be attributed to sex differences in early social relationships. Young girls seem to have more intense, intimate, and mutual friendships, which may lead to a subsequent development in their awareness of others' mental and emotional states (Clark & Reis, 1988; Hughes & Dunn, 1998). Even by the age of three, sex disparities can be observed, with girls having more advanced ability than boys to interpret other people's thoughts and intentions (Happé, 1995). Moreover, girls are apparently encouraged to discuss and participate more in the expression and perception of emotion (Brody, 1985). For a meta-analytic review of sex differences in facial emotion perception abilities in children from birth through to adolescence, please refer to McClure (2000). This article describes differences in social and neural development between girls and boys.

A number of structural differences in the brain exist between men and women, particularly structures implicated in emotion. For a review, see Good and colleagues (2001). Differences in neural responses to emotional stimuli between men and women have been reported. For instance, functional magnetic resonance imaging (fMRI) research and studies of visually-evoked potentials have shown that men displayed more extensive activity whilst viewing pleasant pictures than women (Kemp, Silberstein, Armstrong, & Nathan, 2004; Lang et al., 1998). Furthermore, this activity in males may be concentrated in the occipital cortex (Lane et al., 1999; Lane, Reiman, Bradley et al., 1997). Following presentation of emotion stimuli, females show more activation in basal ganglia overall, yet males show more specific activity in the striatum. Interestingly, women's electrodermal responses to pleasant images are smaller than men's (Lang, Greenwald, Bradley, & Hamm, 1993). Thus, men and women diverge in their biological responses to emotional stimuli. McClure and collaborators (2004) reported that women showed greater relative amygdala activation than men inreponse to threat stimuli, yet these sex differences were not apparent in adolescents (aged 9-17). Sex differences in response to threat may, therefore, vary across development.

For more information regarding sex differences in neural activity to emotion stimuli, please refer to the meta-analysis study by Wager and colleagues (2003). With neuropsychological and imaging studies, however, it is not clear how structural or activation differences relate to behavioural disparities between men and women.

Not all research is conclusive of a female advantage for emotion processing. No sex differences have been reported in some studies (Killgore, 2000b; Maccoby & Jacklin, 1974); a male superiority for interpreting emotion-congruent expressions has been observed in another, whereby males interpret emotional expressions more accurately that are similar to their own emotional state (Toner & Gates, 1985). Female difficulties in perceiving anger have also been reported (Rotter & Rotter, 1988; Wagner, MacDonald, & Manstead, 1986). Thus, it is not clear whether there are distinct sex differences in emotion processing, or whether other variables such as personality characteristics or type of stimuli could explain these inconsistencies.

6.2.1 Method

This is covered in detail in Chapter 4. There were 81 women and 56 men in total. They listened to eight representations of each vocal emotion of anger, disgust, fear, happiness, and sadness, and categorised each sound with one of the five labels.

6.2.2 Results

The raw scores for male versus female participants are shown in Figure 6.1. Data were submitted to a between-subjects ANOVA, with Greenhouse-Geisser corrections. Factors of interest were sex of participants (male, female), as the between-subjects variable, and recognition accuracy rates per emotion (anger, disgust, fear, happiness, sadness), as the within-subjects variable.

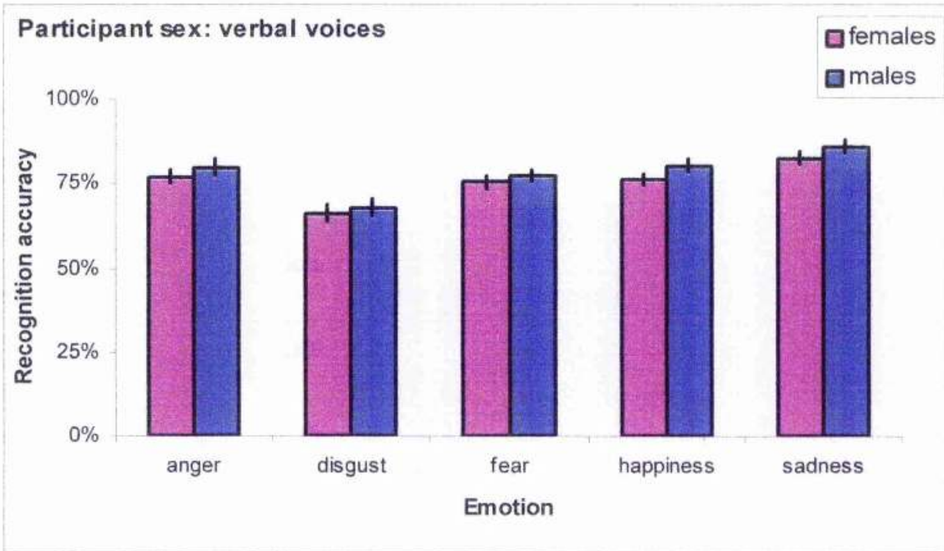


Figure 6.1: Recognition accuracy rates for vocal emotion perception by men and women. The bars represent standard error.

A significant effect of emotion was revealed, $F_{(3.64, 491.40)} = 19.40$, $p<0.001$. There was no significant emotion by sex of perceiver interaction, $F_{(3.64, 491.40)} = 0.13$, $p=0.973$. There was, however, a trend for men achieving higher accuracy rates than women, $F_{(1,135)} = 3.43$, $p=0.066$.

6.2.3 Discussion

Despite no significant differences in male's and female's vocal emotion recognition abilities, there seems to be a trend indicative of a slightly greater accuracy in the ability of men to perceive vocal emotion.

This is inconsistent with the bulk of sex literature, perhaps because vocal stimuli were used in the present study. Given that the difference reported in this study is small, it may well be negligible and not warrant further discussion.

It has been predicted on the basis of Chapters (3, 4, and 5), that men and women might differ significantly in their perception accuracy of disgust. As mentioned earlier, women have been reported to be more easily disgusted than men (Haidt et al., 1994), and high disgust sensitivity has been related to disturbed disgust perception (Sprengelmeyer, Young, Pundt et al., 1997). In the analysis presented in this chapter, differences between males and females in disgust perception were not manifest by accuracy rates.

6.3 Sex of the expresser: male versus female actors (stimulus-based exploration)

The second analysis explores the influence of sex of the actors who convey the emotional vocalisations.

Many studies indicate superiority in females in their ability to express emotions facially (Biehl et al., 1997; Buck, 1979; Buck, Miller, & Caul, 1974; Gitter, Black, & Mostofsky, 1972; Kirouac & Doré, 1985), and gesturally (Brody & Hall, 2000).

By contrast, studies of expressions of specific emotions reveal a different pattern. Male happy and sad faces have been reported to be easier to recognise than female faces (Thompson, 1983). No general expresser sex differences have been observed in another study of portrayals of facial emotion (Wallbott, 1988), yet recognition of specific emotions did vary, dependent on the expresser's sex. Women were markedly better at communicating fear and sadness, whereas men's portrayals of anger were superior to those by women. According to a number of other studies, facial anger seems to be more readily communicated by men (Brody & Hall, 2000; Coats & Feldman, 1996). Furthermore, according to other research, men are more likely than women to show anger, regardless of the context, (Kelly & Hutson-Corneaux, 1999), which may be associated with the idea that women suppress socially unacceptable emotions, such as anger and disgust (Brody, 1985).

In the face, the zygomatic muscle is involved in smiling. It is often activated involuntarily in moments of pleasure, or in response to pleasant stimuli, but also in the form of grimaces in response to feeling negative emotions or seeing/hearing unpleasant stimuli. Schwartz and colleagues (1980) used electromyography (EMG) to measure involuntary activity in facial muscles in response to emotional imagery. In these circumstances, women generate greater facial EMG patterns than men. During the presentation of emotional images, women also show a greater concordance between zygomatic EMG activity and affective valence of the images displayed than men (Dimberg & Lundquist, 1990; Greenwald et al., 1989). These differences suggest that emotional expression in males and females may involve different response systems.

The sex of actors expressing vocal emotion and its effect on emotion perception has rarely been investigated. Scherer and colleagues (2001) reported a sex effect, and sex of actor by vocal emotion interaction. They do not discuss where this interaction might be based, since their study only employed four actors and they did not deem further analysis necessary. By contrast, in some other studies, the sex of the expresser's voice was not reported to play a role in emotion perception (Brody & Hall, 2000; Hall, Carter, & Horgan, 2000a; Pell, 2002). Thus, it is apparent that investigations of the effect of sex of the expresser on the clarity of emotion portrayals are inconsistent and inconclusive.

The aim of the next part of this study is to examine the sex of the actor and its effect on vocal emotion perception, since it is not clear whether these factors may be related.

6.3.1 Method

This is covered in detail in Chapter 4. There were four male and four female actors, who each spoke one vocal phrase in the emotion categories of anger, disgust, fear, and sadness. For happiness, there were five female and three male vocalisations. To overcome this discrepancy, the mean recognition rate for all of the female and all of the male voices was calculated for each emotion. One hundred and thirty seven participants listened to these stimuli (see Chapter 4 for more information).

6.3.2 Results

Mean scores were calculated for recognition accuracy of male versus female vocal emotion stimuli. These are shown in Figure 6.2.

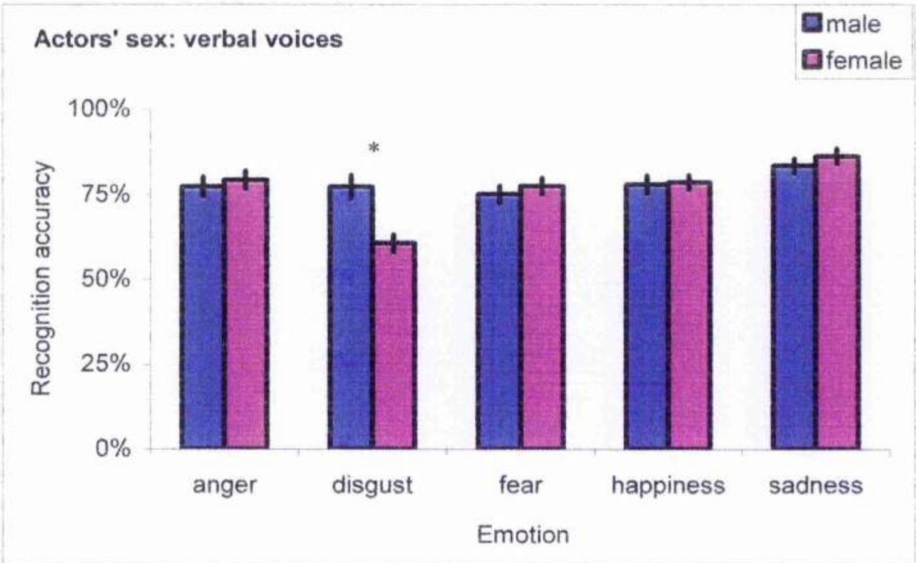


Figure 6.2: Recognition accuracy rates for male and female vocal representations of five different emotions.

* $p<0.001$

The data were submitted to a within-subjects ANOVA and a significant effect of emotion was revealed, $F_{(4,540)} = 5.25$, $p<0.001$. Sex of voice also had an effect, $F_{(1,136)} = 25.12$, $p<0.001$, and this was qualified by a significant sex of voice by emotion interaction, $F_{(3.71,\ 505.01)} = 19.33$, $p<0.001$. Paired-samples t-tests were used to explore the source of this interaction and male representations of disgust were more accurately recognised than female representations, $t(136) = 6.53$, $p<0.001$. For other emotions, there were no differences, $p>0.087$.

6.3.3 Discussion

In the current set of stimuli, female portrayals of disgust are not as readily recognised as male portrayals of disgust. Pell (2002) reported a similar outcome, with facial expressions of disgust, but not vocal representations. This could be related to inhibition of socially unacceptable displays of emotion by women (Brody, 1985). It is also plausible that the women in this sample are simply worse actors. There is also a suggestion that male fear may be harder to interpret than female fear. These findings are unusual and will be discussed in more detail in the General Discussion (Section 6.5).

6.4 Interactions between sex of observer and expresser of emotions

There is a paucity of research exploring whether the sex of the actor might influence the interpretation of emotions differently when observers are either male or female.

Beall (1995) presented emotional expression stimuli (visual and vocal combined) to groups of males and females. The participants were asked to rate the intensity of happiness or anger felt by the expresser. For same sex judgements (women perceiving women, men perceiving men), ratings of happiness intensity were much higher than across sexes (women perceiving men, men perceiving women). This study infers that there may be some sort of sex-influenced congruence in positive emotion perception. This sex congruence extends to emotion recognition studies.

Wagner and colleagues (1986) found that women were more accurate at recognising female facial emotion than male facial emotion. Moreover, according to Rotter and Rotter (1988), despite females being superior at interpretation of facial emotion generally, men were remarkably better than women in interpreting *male* facial expressions of anger. Erwin and colleagues (1992) described a male advantage for perceiving sadness represented by the face and this advantage was particularly enhanced for male faces.

Although there is little research that has explored the interaction between sex of actor and sex of observer in emotion perception tasks, there seems to be an inclination towards greater sensitivity for sex-congruent stimuli. This means that men are more perceptive to emotional displays by other men and vice versa for women. Yet much of this research is limited to explorations of facial emotion.

The aim of the following study was to investigate the interaction of sex of expresser with sex of perceiver and emotion recognition accuracy for vocal displays.

6.4.1 Method

The method is described in Chapter 4. 81 females and 56 males were compared in their abilities to perceive male anger, female anger, male disgust, female disgust, male fear, female fear, male happiness, female happiness, male sadness, and female sadness. Each condition is represented by mean recognition accuracy for the all of the actors' or all of the actresses' depictions of each emotion.

6.4.2 Results

Mean recognition accuracy scores for each emotional display (male and female) by the two groups is presented in Figure 6.3.

The data were investigated using a multivariate statistical ANOVA. The between-subjects variable was sex of participant (male, female). The within-subjects variables were sex of voice (male, female) and emotion (recognition accuracy rates for anger, disgust, fear, happiness, sadness).

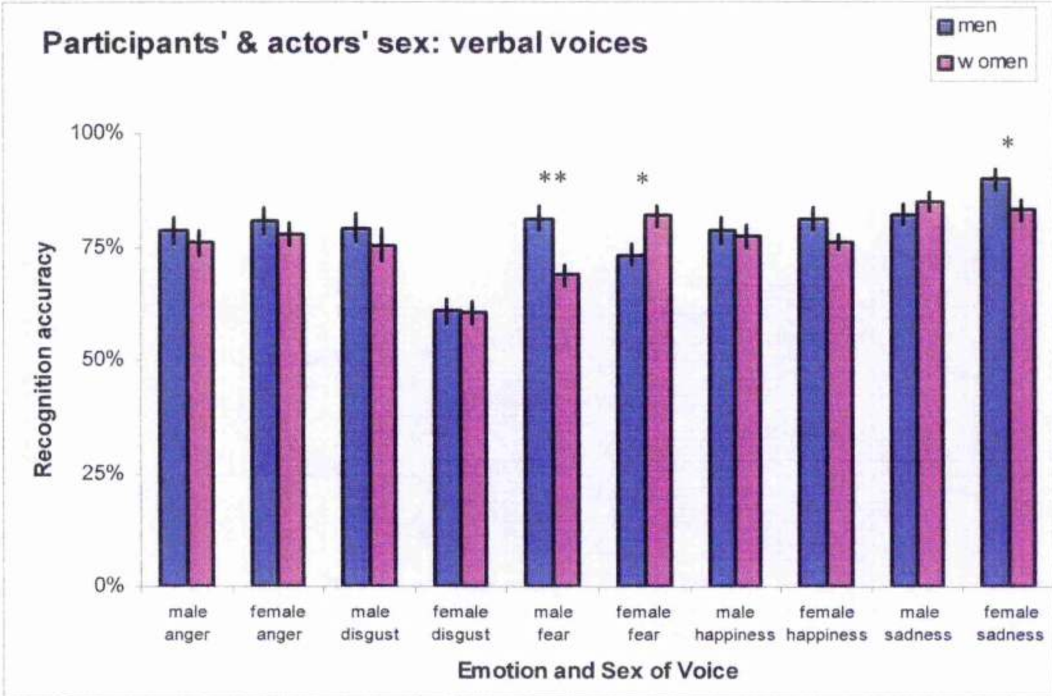


Figure 6.3: Men and women's differential recognition responses to male and female vocal emotions.
** $p<0.005$, * $p<0.05$

There was a main effect of emotion, $F_{(3.45, 466.20)} = 16.47$, $p<0.001$. A marginal effect of sex of voice, $F_{(1,135)} = 3.77$, $p=0.05$, was again qualified by a significant emotion by sex of voice interaction, $F_{(4,540)} = 11.91$, $p<0.001$, which is compliant with the finding that male representations of disgust attain higher accuracy rates than female representations of this emotion. Sex of participant did not have a significant effect, $F_{(1,135)} = 2.41$, $p=0.123$, nor did it interact with sex of voice, $F_{(1,135)} = 1.52$, $p=0.220$. This indicates that when sex of voice is taken into account, there is not significant difference between male and female participants in their overall emotion recognition abilities. Sex of participant and emotion did not interact, $F_{(4,540)} = 3.54, 466.20) = 0.04$, $p=0.994$. Of more interest here, a significant emotion by sex of voice by sex of participant interaction can be reported, $F_{(4,540)} = 5.67$, $p<0.001$.

Post-hoc analysis revealed that the emotion by sex of voice by sex of participant interaction has its roots in fear perception. Recognition of male fear was significantly better for men than women, $F_{(1,135)} = 11.80$, $p<0.005$. There was a female advantage for the recognition of female fear, $F_{(1,135)} = 5.86$, $p<0.05$. Men were also more accurate at perceiving female sadness, $F_{(1,135)} = 4.17$, $p<0.05$. Recognition for other emotions did not differ between the sexes, $p>0.10$.

6.4.3 Discussion

This analysis suggests that men and women show sex-congruent patterns in their perception of fear. Specifically: participants were better at perceiving fear displayed by an actor of their own sex. Men also demonstrate a greater ability to perceive sadness exhibited by women. These results are anomalous with stereotypical views that women have greater expertise in decoding emotional displays, and that women should emit emotional expressions more clearly.

6.5 General discussion

While social stereotypes suggest that women are more emotionally expressive and more sensitive to emotions displayed in others, the current set of data indicates that neither of these conventional views is applicable to the population explored and the vocal emotion stimuli used in the current experiment. Observed results contrast with stereotypical patterns of data, i.e. males inhibit the expression and perception of most emotions, whereas females will only suppress the expression and attribution of socially unacceptable emotions (Brody, 1985).

When sex of voice is considered, there are no differences between men and women in their ability to detect subtle emotional nuances from vocalisations. It can be observed that disgust represented by male voices is more easily interpreted than disgust communicated by female voices. Furthermore, the present studies also show that sex of the actor and the sex of the perceiver interrelate and influence fear and sadness perception accuracy markedly. Men are more sensitive to fear displays by other men than by women, and reciprocally, women are more sensitive to fear displays by other women than by men.

6.5.1 Sex of observer

The lack of female advantage for perceiving emotions in this current study may be related to the use of vocal stimuli. For instance, differences between men and women in their recognition accuracy of emotions represented by the auditory channel, might be attenuated in comparison to when the emotional representation is in the visual channel (Rosenthal, Hall, DiMatteo, Rogers, & Archer, 1979). Therefore, it is not clear whether the results reported here are representative and consistent with previous emotion research.

It had been proposed that findings reported in Chapters 3 and 4 (where an effect of mood on disgust interpretation has been reported), might have their roots in the greater prevalence of women in the populations that have been tested, and perhaps some associated disturbed disgust perception. The present study has not, however, highlighted any differences in vocal disgust perception between men and women. See Chapter 7 for an investigation of interactions between sex, mood and emotions.

6.5.2 Sex of actor

The analysis revealed few differences between men and women in their ability to communicate emotions. None of the actors in the vocal experiment were trained actors, nor were any of the phrases spoken spontaneously. It could be argued that the vocal phrases represent caricature-like sounds. The conditions in which the vocal recordings were made limit the extent to which the current findings and conclusions can be applied to a wider population and contrasted with past research.

Nevertheless, the current results have shown that men's expressions of disgust are recognised with relative ease in contrast with women's in the current stimulus set. Perhaps differential disgust sensitivity levels between sexes are exhibited in their display or representation of this emotion. Women might believe their expressions are clearer than they actually are, because they are more sensitive to their disgusted internal state. Hence, they are too subtle at acting disgusted. A further explanation for this may relate to the aforementioned proposal by Brody (1985) that women are less likely to express socially unacceptable emotions. Thus, representations of disgust by women might not be familiar to observers.

6.5.3 Interactions between sex of observer and sex of actor

The current pattern of results, which suggests a sex-congruent finding for fear perception, may be explained in terms of threat processing. Across development, females seem to be more sensitive to anger-related cues than males (Goos & Silverman, 2002; Hall, 1978; McClure et al., in press; McManis, Bradley, Berg, Cuthbert, & Lang, 2001). This sensitivity is manifest in recognition accuracy rates, physiological changes, neural activation, and reaction speeds to stimuli. As far as past research is concerned, however, there seems to be little evidence of any sex differences in sensitivity to fearful stimuli. Yet the emotions of fear and anger are highly inter-related. This is not on the basis of their expressive, physiological, or experiential qualities, but because anger displays often provoke fear displays. As a consequence, any explanations for patterns in perceptive ability for one could be associated with the other.

There are two potential explanations for the sex-congruent pattern of fear recognition as observed in this study, which may be combined to provide a more reasonable account. The first is from a biological perspective. This would relate the discerned sex disparities to different perceptive capacities of men and women. The second, socio-cognitive, perspective proposes that emotion perception is a learned response, which improves with experience, and consequently, men and women may have different learned capacities to display and perceive fear, as a product of different experiences of the emotion (Goos & Silverman, 2002).

Portrayals and experience of aggression might differ significantly between men and women. This could explain the current set of results from a socio-cognitive perspective. For instance, aggressive displays *between* women and *between* men are fairly common (Campbell, 1999). As in several species, cross-gender competition and conflict are rare in comparison. Thus, it can be argued that intra-gender aggressive encounters are more probable, and the implications of this are that intra-gender displays of fear would also be more common than during interactions across sexes. If perceptive abilities are experience-reliant, then increased exposure to certain displays will improve perception accuracy of that emotion. This could explain the sex-congruent pattern in the perception of fear.

In accordance with this proposal, Goos and Silverman (2002) found that women recognised female facial anger better than their male counterparts. No significant differences were found for fear, although there was trend for women to have reduced accuracy at recognising male facial fear. Combined with the current results, there is a strong argument in favour of a sex-congruent element in the perception of threat-related emotions.

Since the vocalisations presented in the current study are feigned renditions of responses to threatening situations, rather than true representations of fear, it is plausible that recognition of such vocalisations benefit from experience such as play-fighting. This argument ultimately relies on the idea that men and women differ in their exhibition of fear responses, either in true or in simulated situations. Should a socio-cognitive explanation of sex differences be valid, then it would be expected that differences in social learning for boys and girls exist. Indeed, there is substantial developmental literature, which suggests that early experiences between boys and girls vary – not just from peer interactions, but within parent-child interactions too (McClure, 2000; McClure et al., in press). As previously discussed, young girls and boys differ in their approaches and adult encouragement of emotional experiences and expression.

It is surprising that sex-congruence for anger perception in the vocal domain is not replicated in the present data, especially given that it has been established in other research using visual stimuli (Goos & Silverman, 2002; Rotter & Rotter, 1988). Perhaps anger is carried more clearly and universally by the voice than by the face, regardless of sex of the communicator. As proposed in Chapter 10, this might reflect the evolutionary origins of each emotion: certain emotions might be displayed most conspicuously through particular channels, in order to best communicate that sentiment.

6.5.3a Mirror systems and emotional empathy

From an evolutionary frame of reference, it is possible that our ability to infer mental states of others might be rooted in the capacities of neural mechanisms, such as mirror neurons (please see Section 1.5.4 for more details). These are neurons that are activated in response to the performance of an action, and also when this action is viewed being executed by someone else. It is believed that these neurons may play a role in the interpretation of others' intentions. This could involve matching another's state onto our own corresponding neural representation patterns (Gallese & Goldman, 1998), in order for us to assign a label to this state. There is emerging evidence for audio-visual properties of mirror neurons, thus they may be implicated in the interpretation of auditory cues as well (Barraclough, Xiao, Oram, & Perrett, 2003; Fadiga et al., 2002; Kohler et al., 2002).

Wicker and colleagues (2003) found that induced feelings of disgust activated the same neural mechanisms within the anterior insula, and anterior cingulate cortex, as observing facial expressions of disgust. This is an important study, as it demonstrates the existence of mirror systems, which are activated when perceiving emotions in others and when feeling that emotion oneself. Such mechanisms may have a role in emotion recognition. Since the activation of mirror neurons requires quite precise actions (Keysers et al., 2003) and these neurons are activated earlier by familiar stimuli (Grèzes et al., 2004), if men and women communicate the emotion of fear in subtly different ways, they may be better able to map expressions by someone of the same sex onto their own representation of that emotion. This could lead to a greater ability to identify that emotion. The proposal that activity of mirror neurons could explain the present results is reliant on the relation between animal and human neural systems, the specificity of responses to subtly distinct actions by the mirror neurons, and imperatively, the differential communication of fear vocally by men and women. For more discussion regarding mirror neurons, please see Section 1.5.4.

6.5.4 Sadness

The observation that men are more sensitive to female sadness is unexpected. It is plausible that females do not recognise the sadness vocalisations in the current study simply because they are acted rather than natural representations of sadness, which would constitute more familiar vocalisations.

6.5.5 Summary and conclusion

In conclusion, the present data provide evidence for a sex-congruent influence on emotion perception accuracy. This effect is limited mainly to fear perception and may be derived from the combined effect of experience-dependent socialisation, and the ability to see one's own emotions mirrored in the emotions of others. It is proposed that differential experiences of men and women contribute to this finding, since aggressive encounters between men and women are less common than same-sex confrontations. It is also suggested that men and women may vocalise fear by different means, and as a consequence, mirror neurons and familiarity may influence the perception of fear in same-sex voices.

Within the current results, there is no female advantage for emotion *recognition*, which conflicts with established research. This may be explained because the stimuli employed were emotional vocalisations, rather than faces.

The investigation did not reveal a female superiority for the *display* of vocal emotions either. Indeed, women were less accurate in representing vocal disgust than men. It is postulated that this may reflect women's disturbed disgust sensitivity. Otherwise, it may be a consequence of females' suppression of socially unacceptable emotional displays. Only four actors of each sex represented these emotions, so any conclusions regarding the display of vocal emotions on the strength of this data should be questioned somewhat.

A caveat for emotion perception researchers on the basis of these current findings would be to ensure that sex of the stimuli is taken into account if presenting the stimuli to specific audiences. Underestimating the role sex may play in the processing of emotions could have consequences for this field of research.

7 SEX DIFFERENCES, MOOD, & EMOTION RECOGNITION

Few studies have explored the interaction between sex of participant, sex of actor, mood, and emotion recognition. The purpose of this chapter is to combine analysis from Chapters 4 and 6 in order to examine to what extent these three factors may interact.

7.1 Introduction

As proposed in Chapters 3 and 4, the influences of mood states and traits on the recognition of disgust might actually be mediated by sex differences in disgust perception. Despite the previous chapter (Chapter 6) revealing that women were no different to men in their recognition accuracy for disgust, it is still plausible that perhaps moods and sex of actor interact to have some influence on disgust perception or on the perception of other emotions. Investigating this might allow further interpretation of the findings of the earlier studies outlined in Chapters 3, 4, and 6.

7.1.1 Summary of mood and emotion recognition

Chapters 3 and 4 summarise research studies that show the impact of mood on emotion perception. Previous research has generally shown that moods in non-clinical populations seem to have a congruent effect on emotion perception. Chapters 3 and 4 highlighted differences in disgust perception between those with varying mood states and traits, such that people with positive and negative moods were significantly worse at recognising disgust from the voice in comparison to a control group, and those that were in negative moods had difficulties interpreting disgust from body movements. The studies also revealed that mood groups could be differentiated in terms of their incorrect emotion labelling choices, not just their overall sensitivity to emotional stimuli. Initially, it was suggested that the disgust impairment could be attributed the greater incidence of females in these groups. The analysis of sex differences in Chapter 6 indicates that the disgust finding is unlikely to be explained by the sex imbalance in the groups, unless there is some sort of interaction between sex of actor, sex of participant, mood, and emotion perception.

In accordance to the data presented in Chapters 3 and 4, Murray (1992) found that while those with lower depression scores had an emotion perception advantage, the participants with higher depression scores were also less accurate at recognising disgust than the others, but she examined sensitivity to facial expressions of emotion. This is of particular interest in this thesis, since disgust appears to be central to group differences in mood reported here (Chapters 3, 4, and 5).

7.1.2 Summary of sex differences and emotion recognition

Chapter 6 summarises key research exploring the influence of sex of participant or sex of the expresser on emotion perception. The study outlined in Chapter 6 demonstrated an emotion by sex of participant by sex of stimulus actor interaction. Men were more accurate than women at perceiving fear vocalised by another man and women were superior to men in interpreting female fear vocalisations. There was also evidence for a male advantage in perceiving female sadness. These sex differences were unexpected. It is not clear whether such sex differences may be mediated by mood.

The present study seeks to explore the influence of sex of actor, sex of participant and mood of participant on vocal emotion perception.

7.2 Method

7.2.1 Participants

The details of the dysphoria control group and the dysphoric group are summarised in Section 4.2.1.

7.2.2 Stimuli and procedure

The stimuli for this task are summarised in Section 6.4.1.

7.3 Results

The recognition accuracy scores for each emotion, represented by males or represented by females, were analysed using a mixed-design MANOVA, with dysphoria group (control, dysphoric group) and sex of participant (male, female) entered as between-subjects variables[1].

7.3.1 Anger

The analysis revealed no effect of participants' sex on the recognition accuracy scores for either male or female anger, $p>0.42$ in both cases. Nor was there an effect of dysphoria group on the results, $p>0.67$ for both male anger and female anger. The sex of participant by dysphoria group interaction was not significant either, $p>0.36$ for both male and female anger.

[1] An overall ANOVA (comparing all emotions) was also carried out, revealing the same effects as presented here. Sections per emotion were provided to enable specific emotions to be examined more closely.

7.3.2 Disgust

Sex of participant did not have an effect on the perception of male or female disgust, $p>0.42$ in both cases. Dysphoria groups did not differ in their recognition of male disgust, $p>0.1$. By contrast, the dysphoric group found female disgust more difficult to interpret than the control group, $F_{(1,135)} = 8.93$, $p<0.005$. The sex of participant by dysphoria group interactions were not significant, $p>0.30$ for both male and female disgust.

7.3.3 Fear

There were significant differences between male and female participants' recognition accuracy of male fear, $F_{(1,135)} = 11.65$, $p<0.005$, and female fear, $F_{(1,135)} = 6.04$, $p<0.05$. Men were more sensitive to male fear, and women were more sensitive to female fear (see Chapter 6). There was no effect of dysphoria group, $p>0.53$ in both cases. Sex of participant and dysphoria group did not interact for either male fear or female fear, $p>0.10$ for both.

7.3.4 Happiness

There was no influence of sex of participant on recognition accuracy of male or female happiness, $p>0.10$ for both. Dysphoria groups did not differ in recognition of female happiness, $p>0.63$. The dysphoric group were marginally better at interpreting male happiness than the control group, $F_{(1,135)} = 3.25$, $p=0.074$. The interactions between sex of participant and dysphoria group were not significant, $p>0.47$ for both male and female happiness.

7.3.5 Sadness

Sex of participant had no effect on the recognition of male sadness, $p>0.36$, but there was an effect on the recognition of female sadness, $F_{(1,135)} = 4.34$, $p<0.05$, with men being more accurate in their recognition of these vocalisations. There was no influence of dysphoria group on these results, $p>0.22$ for both. The sex of participant by dysphoria group interaction was not significant, $p>0.312$ for both male and female sadness voices.

7.4 Discussion

The current analysis was designed to explore the relationship between recognition accuracy rates per emotion, mood, sex of actor, and sex of participant. The present results re-establish the findings outlined in Chapters 4 and 6. No interactions between emotion recognition accuracy, sex of participant, sex of actor, and mood, have been observed.

7.4.1 Disgust and mood

Negative moods have an effect on the perception of disgust, as outlined in Chapters 3 and 4. The present results reveal that this impact is limited to the perception of female disgust vocalisations, rather than male disgust vocalisations. In Chapter 5, it was proposed that the impairment in perceiving disgust by dysphoric groups might be related to the ambiguity of the stimuli. Female disgust stimuli have the lowest recognition accuracy rates of all the stimuli, even in the control group. Therefore, this bolsters the argument that negative moods have a greater tendency to affect the recognition of difficult stimuli.

7.4.2 Sadness and mood

In Chapter 6, it was reported that men are more sensitive to female vocalisations of sadness than women. The present study revealed that dysphoric mood had no influence on this result. It is plausible that females do not recognise the female sadness vocalisations in the current study simply because they are acted rather than spontaneous representations of sadness, which would be more familiar for interpretation.

7.4.3 Fear and sex-congruence

The sex-congruent effect for the perception of fear vocalisations reported in Chapter 6, cannot be attributed to the presence of negative moods, as dysphoria group had no influence on the detection of fear. Moreover, dysphoria did not interact with sex of participant in the recognition of fear. For more discussion on this finding, please see Chapter 6.

7.4.4 Conclusions

In summary, the present study has re-established the findings of previous chapters (Chapters 4 and 6). The current results demonstrate that the influence of negative moods on disgust perception, outlined in Chapter 4, is rooted in the perception of female disgust representations. Female voices representing disgust are difficult to recognise and this difficulty is exacerbated in dysphoria. This adds weight to the argument that negative moods affect the interpretation of ambiguous or difficult stimuli. This speculation could be explored in future research studies.

8 AGEING & EMOTION RECOGNITION

A number of studies have shown deterioration in emotion recognition with age. Some studies have revealed recognition deficits that are specific to one emotion; some have detected more general deficits. Most research has focused on facial expression perception alone. Consequently, this experiment explores emotional experience and emotion recognition across age groups from faces, voices, and gestures.

8.1 Introduction

The efficiency of most neurophysiological systems declines throughout the life span. The brain itself experiences several changes in structure and chemistry during the normal ageing process. These changes are both qualitative and quantitative, and are associated with gradual deterioration in neurological functioning. The way in which these changes in neurological functioning affect distinct faculties such as emotion processing has yet to be investigated comprehensively. Age-related variations in emotion perception are regularly reported, both in research and anecdotally. Neurological compromise, or alternatively, socialisation differences associated with age could be at the basis of these changes, although it is not clear how neurological degeneration or social learning and competence may relate, since it is unclear precisely how emotion processing from multiple communication channels is affected across the life-span.

There have been a number of studies exploring the potential decline of social understanding in older adults. Some researchers propose that abilities on theory of mind tasks are superior in the elderly (Happé, Winner, & Brownell, 1998), others argue that ageing is related to a marked deterioration in such tasks (Maylor, Moulson, Muncer, & Taylor, 2002), whereas others suggest that there is a disturbance, but this is independent of fluid abilities (that are related to greater mental effort, new or complex information) or crystallized abilities (involving a dependence on previous experience) (Sullivan & Ruffman, 2004b). Variations in emotion perception abilities with age would have an impact on social understanding and relationships, since emotion is the *sine qua non* of human social interaction behaviour. Thus, it is of critical relevance for age-focused research to examine whether emotion perception is stable or variable as humans age. Explorations of this ability could facilitate our understanding of changes in social functioning observed across the life span.

8.1.1 Two theories relating to emotion processing and age

The two key premises related to emotional processing predict differing patterns of change with age. The sociocognitive approach proposes that increased experience of social and emotional environments will lead to an enhancement or maintenance in emotion understanding or recognition (Blanchard-Fields, 1996; Gross, Carstensen, Tsai, Skorpen, & Hsu, 1997). In contrast, deterioration in emotion recognition and understanding, based on neural degeneration associated with age, would be predicted from a neuropsychological stance.

8.1.2 Age-related social cognition research

Older people have an accumulated experience of perceiving emotions across the life-span and, consequently, their ease of recognition may be improved by this familiarity (Magai, 2001). Where younger adults depend on processing abilities, it is possible that their older counterparts will use preserved knowledge and experience to form more effective strategies when executing tests, like emotion recognition tasks (Shimamura, Berry, Mangels, Rusting, & Jurica, 1995).

In other words, the sociocognitive view of the effects of biological senescence on emotion processing is that older people have had more experience, and therefore, practise in interpreting emotions, and consequently, will be better than younger people at this. While other skills may be lost with age, according to this perspective, emotion perception would be maintained, since frequency of use could render it less susceptible to age-related deterioration.

Older people are reported as experiencing fewer negative and more positive emotions in comparison to younger people (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Lawton, 2001; Lawton, Kleban, Rajagopal, & Dean, 1992; Mroczek, 2001). If this is the case, then from sociocognitive view of emotion perception, older people should be better at recognising positive emotions than negative emotions, because these are more familiar. If familiarity is important, it is plausible that emotion recognition abilities are reliant on actors (portraying emotions) being of similar ages to the perceivers.

8.1.3 Age-related neuropsychological research

While the extent of age-related deterioration in regions of the brain is uncertain, the neuropsychological view of a decline in emotion perception has much support because there is considerable evidence implicating emotion processing-related structures in the neuropathology of ageing.

Ageing produces neuronal atrophy (cell deterioration) (Akiyama et al., 1997), and loss of synaptic branching (Adams, 1987). Cell shrinkage, dendritic regression, and reductions in synaptic density also occur as humans get older (Tisserand & Jolles, 2003). Most studies have found a link between cerebral atrophy and cognitive impairments, yet emotion impairments have not been explored comprehensively in older populations.

The popular neuropsychological approach to brain and behaviour considers partially independent yet inter-linking pathways as the basis of functioning. Therefore, some structures or pathways may be more sensitive to ageing than others. The most prominent regions known to be affected preferentially by the effects of ageing include the striatum (Raz et al., 2003), prefrontal regions, and structures of the temporal lobe (see below).

A global decline in frontal lobe functioning, and in medial temporal lobe structures, such as the amygdala and hippocampus, instigated by ageing, is supported by several research studies (Daigneault & Braun, 1993; Driscoll et al., 2003; Hedden & Gabrieli, 2004; Jack et al., 1998; Kaye et al., 1997; Moscovitch & Winocur, 1995; Mu, Xie, Wen, Weng, & Shuyun, 1999; Parkin & Java, 1999; Petit-Taboué, Landeau, Desson, Desgranges, & Baron, 1998; Raz, Rodrigue, Head, Kennedy, & Acker, 2004; Scahill et al., 2003; Smith et al., 1999). The dorsolateral prefrontal regions seem to be affected earlier and more substantially by ageing than ventromedial prefrontal regions (MacPherson, Phillips, & Della Sala, 2002; Rypma & D'Esposito, 1999).

Furthermore, a considerable number of studies have implicated temporal and frontal structures in the processing of emotions (Adolphs & Tranel, 2003; Adolphs et al., 1994; Adolphs et al., 1995; Adolphs et al., 1999; Blair & Cipolotti, 2000; Blair et al., 1999; Broks et al., 1998; Calder, Young, Rowland et al., 1996; Hornak, Rolls, & Wade, 1996; Keane, Calder, Hodges, & Young, 2002; Kolb & Taylor, 2000; Lavenu, Pasquier, Lebert, Petit, & Van der Linden, 1999; MacPherson et al., 2002; Morris, Friston et al., 1998; Morris et al., 1996; Morris, Scott et al., 1999; Scott et al., 1997; Wang et al., 2002). For further information regarding the neuroscience of ageing, please see Hedden and Gabrieli (2004).

Thus, the association between structures that may be compromised by ageing, and their involvement in the processing of emotions, suggests that emotion perception disturbances in an older population should not be unexpected.

8.1.4 Emotion recognition and ageing – importance and background to research

Adults are typically better than children at recognising emotion expressed by faces (DeSonneville et al., 2002). Nevertheless, most cross-sectional research suggests that there is a decline in emotion recognition abilities in later adulthood (Brosgole &

Weisman, 1995; Malatesta, Izard, Culver, & Nicolich, 1987). Several studies propose that this decline is specific to negative emotions, particularly sadness, (Billings, Harrison, & Alden, 1993; Calder et al., 2003; MacPherson, Phillips, & Della Sala, submitted; McDowell, Harrison, & Demaree, 1994; Moreno, Borod, Welkowitz, & Alpert, 1993; Phillips & Allen, in press; Phillips, MacLean et al., 2002; Sullivan & Ruffman, 2004a). There are a few studies that observe preservation or even improvement in some emotion recognition skills with age (Calder et al., 2003; DeSonneville et al., 2002; Moreno et al., 1993).

A general facial emotion processing deficit in older women has been observed in comparison to younger and middle-aged women (Malatesta et al., 1987). In accordance, Brosgole and Weisman (1995) used vocal and facial affect, and music stimuli with three hundred and seventeen participants, ranging in age from 2 years and eleven months, to eighty-three years old. They found that *mood* recognition is best during puberty and that the youngest and very oldest participants had the most difficulties in interpreting the emotional stimuli. This is one of only very few experiments that have examined auditory emotion perception and age. Neither of these two studies explored *specific* emotions though.

Moreno and colleagues (1993) carried out an investigation using Ekman and Friesen's (1976) photographs of basic facial expressions. These are described in Chapter 2. No *overall* difference for the recognition of emotion between three age groups (aged 21-39 years, 40 to 59 years, and 60-81 years) was reported in this study. Exploration of *specific* emotions revealed an interesting pattern though: while a greater ability to perceive happiness was observed in the two older groups, the older adults had difficulties recognising sadness, in comparison with the younger and middle-aged groups. A similar finding has been described by Billings and colleagues (1993) that younger women show a negative bias in perceiving emotions from the face, in contrast with older women.

McDowell and co-workers (1994) examined a hypothesis based on the right hemi-ageing theory: if the right hemisphere deteriorates with age, then elderly participants would show a decreased accuracy in perception of facial emotion. This concept was rooted in the idea that the right hemisphere is crucial in the neurobiology of facial emotion perception, especially that of negative emotions (Mandal & Singh, 1990; Sackeim & Gur, 1978; Suberi & McKeever, 1977). In the McDowell and co-workers' study, photographs of facial expressions of emotion were presented either to the right visual field or the left visual field. Elderly people had more difficulties in recognising emotions than younger participants, but this was restricted to negative and neutral facial emotions. There were no real differences in recognition of emotion presented to different visual fields, so this was not consistent with a right hemi-ageing hypothesis. From the studies described thus far, a pattern of negative emotion perception decline across the life span has emerged.

Phillips and her colleagues (2002) also examined individual emotion perception and understanding. The tasks assessed a whole range of emotion perception skills, such as the ability to isolate and identify emotions from texts. They also explored the ability to identify which emotions combine to form secondary emotions. This task was a multiple choice task in which participants had to choose emotions that they thought combined to form a more complex emotion, such as awe. Ekman basic faces were used to test emotion recognition. There were two groups of participants. The first group were aged between 20 and 40 years old and the second group were aged between 60 and 80 years old. No significant overall findings for emotion perception differences between the groups were reported. But when individual emotions were examined, it was revealed that recognition of sadness and anger was impaired in the older age group.

Using Ekman basic faces and the Emotion Hexagon (Young et al., 1997), which is described in Chapter 2, Calder and co-workers (2003) compared the facial emotion recognition abilities of 18-30 year-olds and 50-70 year-olds. Increasing age was associated with a decline in accurate recognition of fear, and less so of anger and sadness. There also seemed to be a partial improvement in recognition of disgust as age increased. This was revealed on both facial expression recognition tasks. This provides further support for the conclusion that there is a decline in recognition of particular negative emotions in the elderly, perhaps relating to neural detrioration in the amygdala with age. Calder and colleagues suggested that the preservation of disgust recognition in the older population may have been related to relative resistance of the insula cortex to neural deterioration with age.

Moreover, Sullivan and Ruffman (2004a) provided support for an age-related decline in facial and vocal emotion perception that is independent of other perceptual changes, and of alterations in processing speed, IQ, and other face processing abilities. In recognising basic Ekman and Friesen emotional faces, older participants had lower accuracy scores for sadness and anger in comparison to younger participants. Whilst viewing one facial expression slowly morphing into another expression, the elderly group were slower to perceive the shift in expression than the younger group. In a second task, using the Emotion Hexagon, participants had to discriminate between two faces, by indicating which is more emotional. The elderly participants were impaired on this task, independent of any perceptual deficit; this was specific to anger, sadness, and to a lesser extent, fear.

In line with this, Phillips and Allen (in press) asked people of all ages to rate the intensity of facial expressions of anger, sadness, fear, and happiness. They reported that older participants perceived sad and happy facial *and* lexical expressions as being less intense than younger participants. MacPherson and colleagues (2002) found that older adults were impaired at emotional identification from faces. This difficulty was particularly enhanced for sadness. Furthermore, MacPherson, Phillips, and Della Sala (submitted) observed that older people had more difficulties and errors than a younger control group on a task that required them to indicate whether faces were displaying the same or different facial expressions. This was particularly true for matches that involved sadness. These studies emphasise that ageing is influential on the perception of negative emotions, particularly sadness.

There seems to be considerable research demonstrating recognition difficulties for negative emotions in older people. This is consistent with both the sociocognitive view of emotion processing, and the neuropsychological stance as well. For instance, if older groups are generally happier than their younger counterparts (Lawton, 2001; Lawton et al., 1992), then according to social cognition researchers, this would lead to decreased contact with negative emotions, both experientially, and perceptively, and thus, worse recognition of negative emotions would emerge. By contrast, neuropsychological research contends strongly for neural systems that are specialised for processing particular emotions (see Section 1.5.2 for more information). That is, each emotion may have a moderately independent neural pathway responsible for its processing. In light of the established research, it could be proposed that the neural pathways responsible for processing negative emotions are damaged somewhat during the ageing process, particularly regions involved in the perception of sadness.

Not all of the studies revealed the same pattern of impairments within emotion perception though, so it is not clear whether older people experience impairments in emotion processing, and whether this deficit would be general, or specific to particular emotions.

8.1.5 Brain, emotion, and ageing

Gunning-Dixon and colleagues (2003) used functional imaging to determine which neural mechanisms may be involved in emotion recognition and how the activity of these mechanisms may change with age. They used photographs of faces displaying happiness, sadness, anger, fear, disgust, and also a neutral pose. Where younger people showed an activation of the amygdala and frontal regions in response to all emotional stimuli in a discrimination task, the older people showed a tendency for activity in left frontal regions chiefly. The authors did not differentiate specific emotional responses. This study provides empirical evidence for an age-related change in the cortical networks involved in the interpretation of emotions.

Despite inconsistencies in age and emotion explorations, there have been no known reports of robust, age-associated impairment in happiness, surprise, or disgust recognition. The amygdala has been implicated via neuropsychological and imaging studies in the processing of fear, anger, and sadness (Adolphs et al., 1995; Blair et al., 1999; Phan et al., 2002), whereas disgust might be mediated by the basal ganglia or insula cortex (Phillips et al., 2004; Sprengelmeyer et al., 1998; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 2003). Yet, the neural substrates for recognition of happiness and surprise are unclear. Ruffman and colleagues (submitted) have proposed a theory for amygdala-mediated decline in emotion perception. The deterioration in fear and sadness perception with age, observed in several studies, is consistent with an accelerated change in the amygdala as humans age. There have been comprehensive research explorations that report changes in the amygdala as humans get older. Mu and co-workers (1999) reported a reduction in the volume of the amygdala in older populations. In accordance, this is true for the temporal lobes as a whole (Coffey et al., 1992; Jack et al., 1998; Kaye et al., 1997; Petit-Taboué et al., 1998). Moreover, Gunning-Dixon and colleagues (2003) reported an attenuated response from the amygdala during emotion processing by elderly individuals.

8.1.6 Rationale

While recent studies have examined the recognition of specific emotions over the life span, most have been based on the assumption that facial expression recognition is a salient and representative component of emotional recognition. This is a precarious assumption, as difficulties in interpreting emotion from one modality might not necessarily generalise to others. In everyday contexts, people use several cues to determine another's emotional state. Therefore, it is of greater ecological validity to examine and compare emotion perception from different forms of expression portrayal, not just static facial expressions. The current study aimed to investigate the influence of ageing on emotion recognition from multiple communication channels: static faces, voices, and dynamic gestures. In turn, this enabled the exploration of the popular neuropsychological theory of emotion recognition, which proposes that specific emotions are processed by partially independent pathways in the brain. Emotions are believed to have evolved for distinct functional purposes and therefore, neural mechanisms underlying them should operate regardless of channel of emotional communication. Such a proposal leads to the hypothesis: if age impairs recognition of particular emotions, then these emotions should be difficult for older people to recognise, *independent of mode of portrayal.*

8.1.7 Current study

In the present study, two measures of each type of emotional expression recognition were implemented to two different age groups (20-49 years, and 50+ years). Each task provides a detailed assessment of emotion recognition from one particular form of emotional expression. It was important to isolate these expressions in order to compare their ease of recognition. The following questions were addressed:

(i) does ageing have an effect on emotion recognition?
(ii) is recognition of emotions that are conveyed by different channels affected to the same degree by ageing?
(iii) is the pattern of recognition ability across component emotions similar for different modalities of expression?

8.2 Method

8.2.1 Participants

Sixty-eight participants volunteered to take part in this study. To maximise sample size, participants were split by age into 2 equal groups (though results were similar when participants were split into 3 groups and upper and lower age groups compared). Thirty-four of the participants were aged between 20 and 49 (mean age = 30.71 years, S.D. = 9.99). These 34 participants comprised the 'Young' group. Ten of the participants in this group were male. The mean estimated Full-scale IQ for this group equalled 118.56 (S.D.= 6.32). This was calculated using the National Adult Reading Test – NART (Nelson & Willison, 1991). See Appendix 1 for the NART.

The second group of 34 participants were aged over 50 years (mean age = 62.12, S.D. = 6.69, range 50 – 80 years). This group is known as the 'Older' group. Again, there were 10 men in this group also. The mean IQ for this group equalled 118.42, (S.D. = 5.87).

A between-subjects ANOVA of the participants' IQ scores produced no significant differences between the groups, $F_{(1,67)} = 0.001$, $p>0.97$. Therefore, any differences revealed in the two groups' scores should not be attributable to IQ differences. The participants' years of education were also measured (younger participants = 17.97 years, S.D. = 2.50; older group = 15.38 years, S.D. = 3.81). All participants had normal or corrected-to-normal vision, and no known neurological damage.

8.2.2 Background tasks

An adapted version of Wolpe and Lang's (1964) 75-item fear schedule was used to examine self-assessed sensitivity to fear. Haidt and colleagues' (1994) 32-item disgust questionnaire measured sensitivity to disgusting stimuli. These tests are described in Appendix 1.

8.2.3 Gestural emotion recognition

The main aim of this set of stimuli was to examine the recognition of emotion by different age groups when expressed gesturally. As a result, the full-light and point-light gesture clips as described in Section 2.2.3 were presented to participants.

8.2.4 Vocal emotion recognition

The vocal emotion recognition tests were incorporated to compare the ease of recognition of emotion from different forms of expression (prosodic verbal and prosodic nonsense). The stimuli and procedures for these tasks are outlined in Chapter 2.

8.2.5 Facial emotion recognition

Facial expression recognition was also explored in this study. Facial expressions, as mentioned earlier, are the most commonly used forms of emotion stimuli. A range of studies (see Section 8.1.4) has reported an age-related deterioration in recognition accuracy of emotional faces, however. It is, therefore, important to use this medium, in addition to other channels of communication to explore emotion perception and ageing. Replication of previous results is imperative before conclusions can be drawn. The Ekman 60 and the Emotion Hexagon were implemented. The two tasks are described in Chapter 2.

8.2.6 Order

Participants were given the gesture tasks first, but the order of point-light and full-light conditions were varied across participants. The two vocal tasks followed (order was varied). These were followed by the Ekman 60 face task, then the Emotion Hexagon.

8.2.7 Statistical analysis

An overall ANOVA could not be carried out comparing emotion recognition across tasks and examining specific emotions because some tasks included surprise, while others did not. For all tasks, data were submitted to a mixed-design ANOVA (with Greenhouse-Geisser corrections where possible). The between-subjects factor was age group (young, old), and the within-subjects factor was recognition accuracy for each emotion (anger, disgust, fear, happiness, sadness, and surprise if included in the task). If a significant or borderline interaction or group difference was revealed, then independent t-tests were administered, equal variances assumed where appropriate, in order to explore impairments in specific emotions. In some cases, performance for individual emotions was contrasted between groups when the emotion by group interaction was non-significant. The reasons for this are described in Section 2.3.

8.3 Results

A description of the results from the various emotions tasks follows.

8.3.1 Background tests

Table 8.1 summarises the results of the two different age groups on the two emotional experience questionnaires.

Table 8.1: Means and Standard Deviations of the Overall Fear and Disgust Questionnaire Scores.

Age group		Fear Questionnaire Overall score	Disgust Questionnaire Overall score
20-49 years old	Mean	105.00*	50.99
	S.D.	36.98	15.74
50+ years old	Mean	86.56*	57.29
	S.D.	36.20	19.67

*Significant age group difference at $p<0.05$

A between-subjects ANOVA revealed a significant difference between the mean scores of both groups for the overall fear questionnaire score, $F_{(1,67)} = 4.32$, $p<0.05$. The younger participants report more sensitivity to fear eliciting situations than the older group. There was no significant group difference for the overall disgust scores, $F_{(1,67)} = 2.10$, $p=0.152$. There was no significant interaction between disgust domain and age groups, $F_{(5.61, 364.52)} = 1.57$, $p=0.142$.

8.3.2 General emotion recognition

Figure 8.1 shows the mean recognition accuracy rates for the different tasks by each age group.

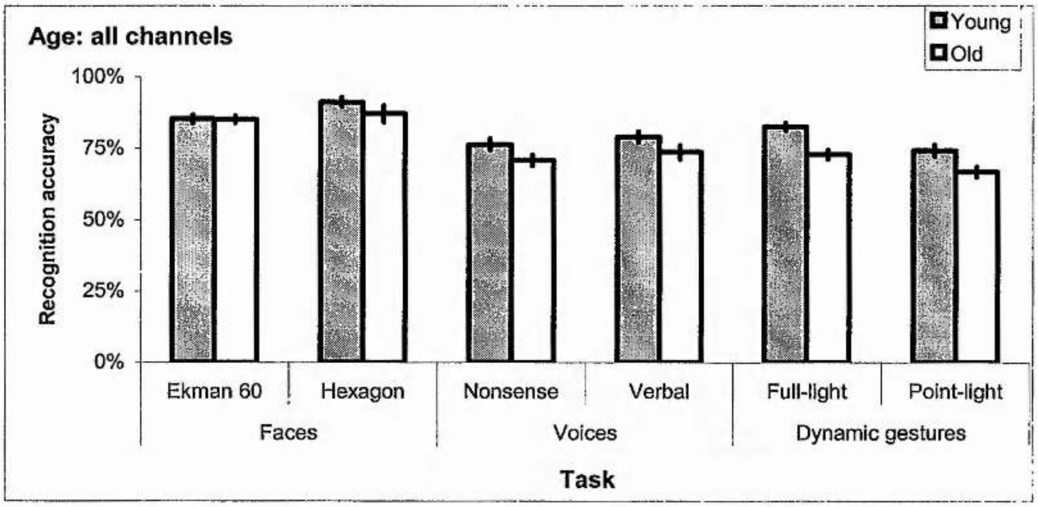


Figure 8.1: The two age groups' recognition accuracy rates for each communication channel.

This figure reveals that mean recognition rates are above chance levels for all conditions. Paired-samples t-tests revealed that, generally, perceiving emotional faces produces higher accuracy rates than other conditions for both age groups ($p<0.001$ for each comparison).

8.3.3 Gestural emotion recognition tests

8.3.3a Full-light gestures

Figure 8.2 summarises the performance results of each age group in the full-light gestures condition.

There was a significant effect of emotion portrayed on recognition accuracy rates, $F_{(3.75, 247.62)} = 30.64$; $p<0.001$. There was also a main effect of age group, with older participants performing less well, $F_{(1,66)} = 20.71$, $p<0.001$. This was qualified by a significant interaction between emotion and age group, $F_{(3.75, 247.62)} = 2.72$, $p<0.05$. Older participants in comparison with their younger counterparts showed significantly worse recognition of happiness, $t(66) = 4.88$, $p<0.001$, disgust, $t(66) = 2.73$, $p<0.01$, anger, $t(66) = 2.42$, $p<0.05$, and sadness, $t(66) = 2.05$, $p<0.05$, but not fear, $t(66) = 0.70$, $p>0.49$.

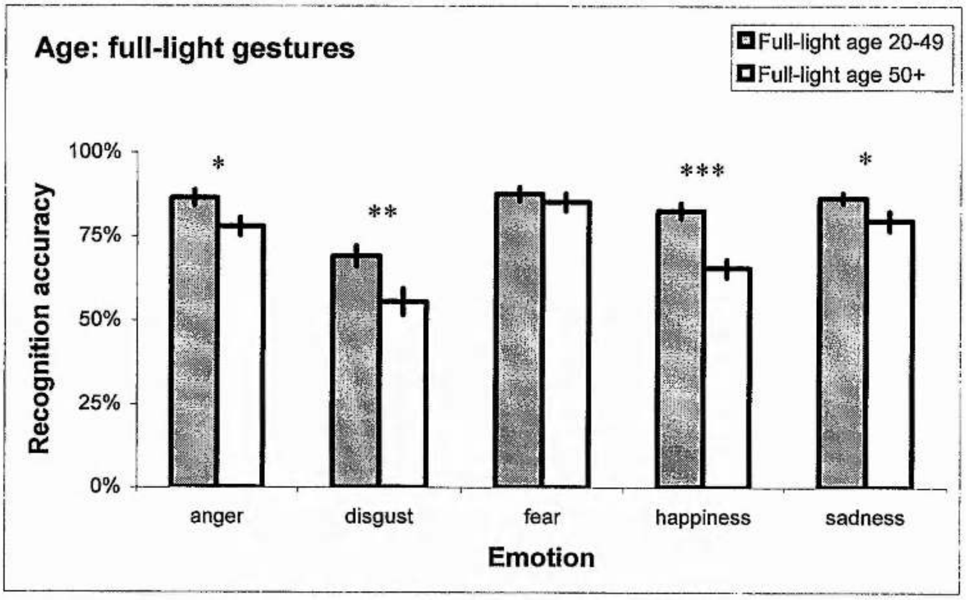


Figure 8.2: The two age groups' recognition accuracy rates for the full-light emotional gesture test.
*** $p<0.001$ ** $p<0.01$ * $p<0.05$

8.3.3b Point-light gestures

Figure 8.3 summarises the results from each of the two age groups in the point-light gestures condition.

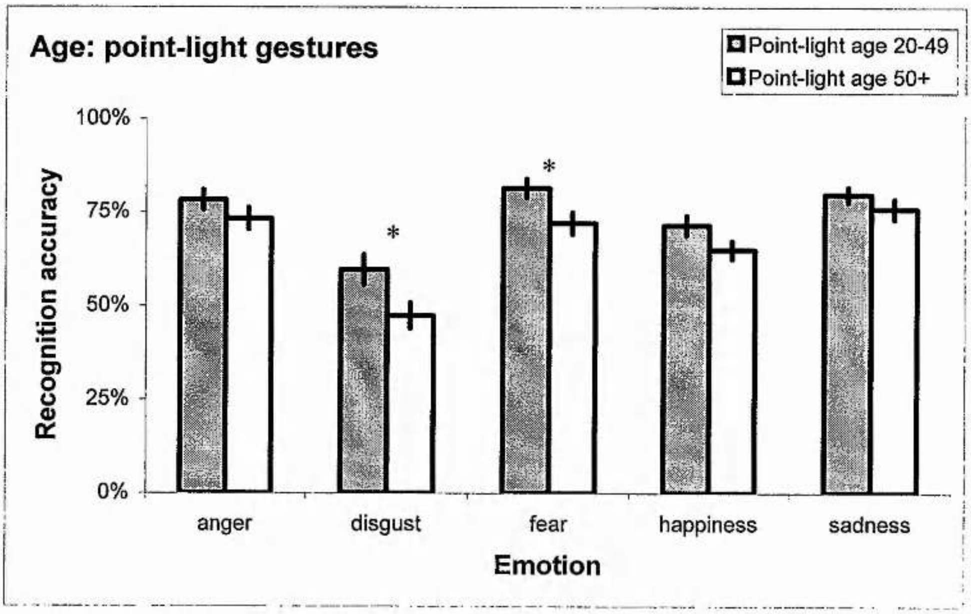


Figure 8.3: The two age groups' recognition accuracy rates for the point-light emotional gesture test.
* $p<0.05$

A significant main effect of emotion portrayed was observed, $F_{(3.76,\ 248.31)} = 33.76$, $p<0.001$. A significant main effect was recorded between the two age groups, with the younger group performing more accurately, $F_{(1,66)} = 7.81$, $p<0.01$. There was no significant interaction between emotion and age group, $F_{(3.76,\ 248.31)} = 0.981$, $p=0.415$. The older group were significantly less accurate at recognising fear, $t(66) = 2.43$, $p<0.05$ and disgust, $t(66) = 2.32$, $p<0.05$. They showed a trend to be worse at perceiving happiness too, $t(66) = 1.83$, $p=0.072$, but not other emotions, $p>0.21$.

8.3.4 Vocal emotion recognition tests

8.3.4a Nonsense vocal emotion test

The summary data are shown in Figure 8.4 from the nonsense vocal emotion test.

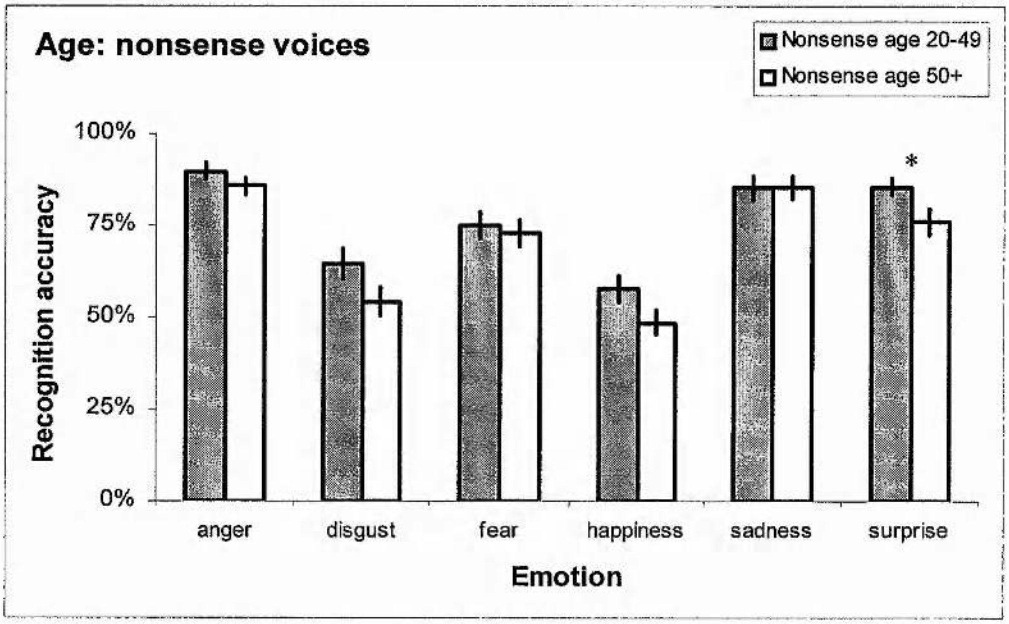


Figure 8.4: The two groups' recognition accuracy rates for the nonsense vocal emotion test.
* $p<0.05$.

There was a significant main effect for emotion, $F_{(4.61,\ 304.07)} = 47.25$, $p<0.001$. The performance of the older participants was worse than that of their younger counterparts, $F_{(1,66)} = 4.37$, $p<0.05$. A significant interaction was not revealed, $F_{(4.61,\ 304.07)} = 1.12$, $p=0.351$. T-tests revealed that it was only recognition of surprise that the two groups differed significantly for, $t(66) = 2.30$, $p<0.05$. Differences in happiness from these nonsense vocalisations showed a trend towards significance, $t(65.42) = 1.84$, $p=0.070$. The older group were not significantly worse at perceiving other emotions: $p>0.25$ for all.

8.3.4b Verbal vocal emotion test

The summary data from the verbal test of vocal emotion are shown in Figure 8.5.

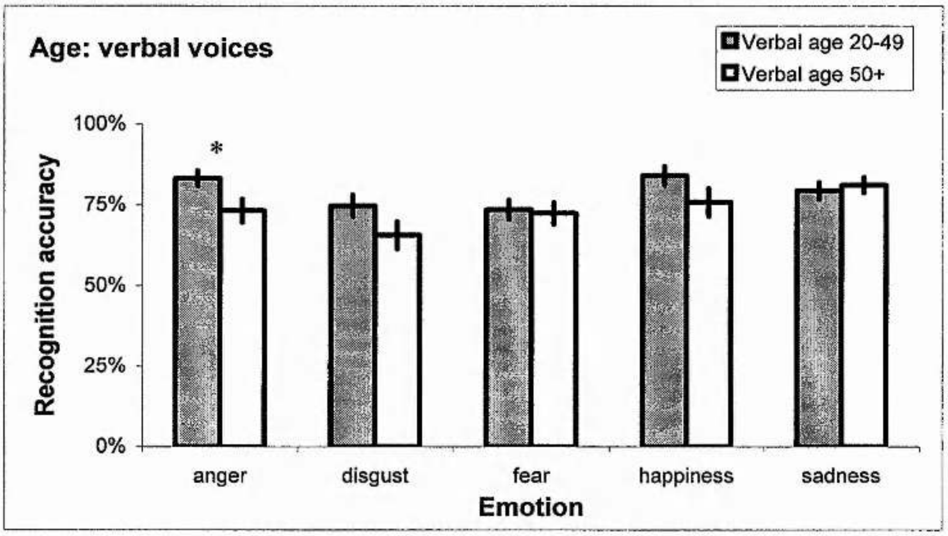


Figure 8.5: The two groups' recognition accuracy rates for the verbal vocal emotion test.
* $p<0.05$

There was a significant effect of emotion, $F_{(3.72,\ 245.45)} = 5.29$, $p<0.005$. The main effect of age group neared significance, $F_{(1,66)} = 3.09$, $p=0.083$. A significant interaction between age group and emotion was not revealed, $F_{(3.72,\ 245.45)} = 1.80$, $p=0.135$. Independent samples t-tests showed that it was only anger for which the older group were significantly worse at interpreting than the younger group, $t(57.19) = 2.32$, $p<0.05$, but not any other emotion, $p>0.095$.

8.3.5a Ekman 60

Participants' mean correct recognition rates for the Ekman 60 faces are portrayed in Figure 8.6.

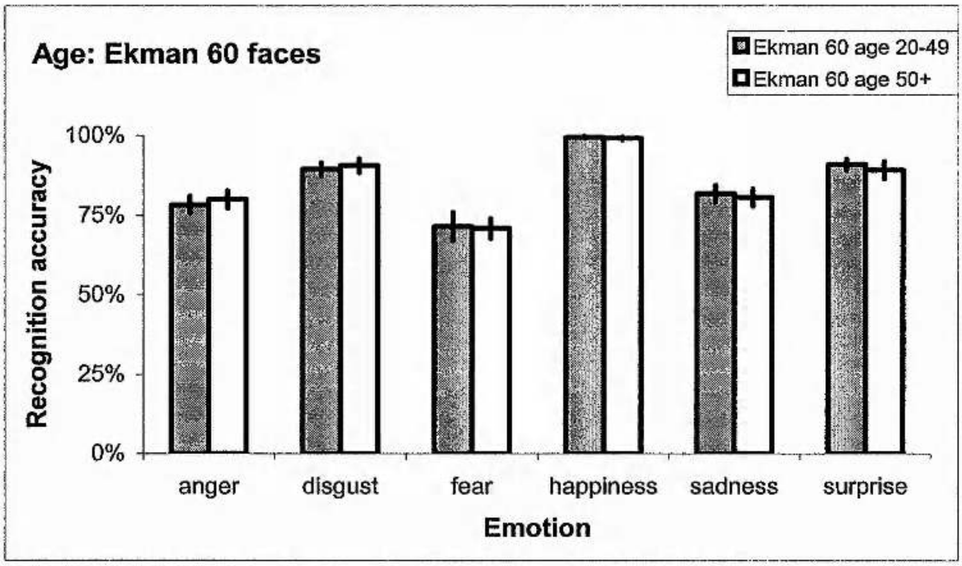


Figure 8.6: The two age groups' recognition accuracy rates for the Ekman 60 test of facial expression recognition.

A significant main effect of emotion can be reported, $F_{(3.53, 232.85)} = 33.96, p<0.001$. No other effects reached statistical significance: emotion by age group interaction, $F_{(3.53, 232.85)} = 0.16, p=0.945$; effect of age group, $F_{(1,66)} = 0.01, p=0.938$. It is important to note that ceiling levels in performance cannot explain the lack of differences in the two groups, except for happiness.

8.3.5b Emotion hexagon

The results from this experiment are summarised in Figure 8.7. There was a main effect of emotion, $F_{(3.69,\ 239.95)} = 11.77$, $p<0.001$. There were no other significant effects recorded: emotion by age group interaction analysis, $F_{(3.69,\ 239.95)} = 1.11$, $p=0.357$; effect of age group,: $F_{(1,66)} = 0.44, p=0.510$.

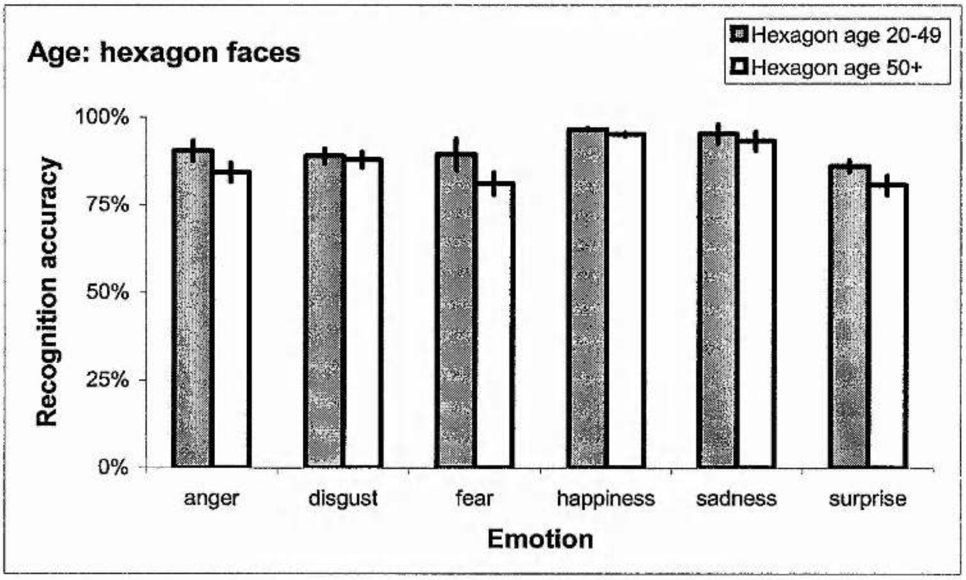


Figure 8.7: The two age groups' recognition accuracy rates for the Emotion Hexagon facial expression test.

8.3.6 Summary of results

There are significant differences in response accuracy between age groups on both of the gesture tasks, and there is also a trend towards significant differences on the vocal tasks. No significant effect of age group was found on the facial emotion recognition tests. Analysis included in Appendix 4 demonstrates that when sex of participant was included as a factor when comparing age groups, the pattern of results resembles the results presented when sex was not included as a factor. The pattern of errors by the two groups are summarised in Tables I-X, Appendix 3. Older participants consistently confused happy gestures with anger, and disgusted gestures with sad more than younger participants in the full-light gesture task. In the point-light task, the young group described angry gestures as disgusted less often than the older group. In both gesture tasks, there were no particular emotions systematically confused with disgust. For both vocal tasks, there was no consistent pattern in confusions, nor did this differ between age groups.

8.4 Discussion

This study was designed to explore changes in emotion perception observed across age groups. As an interesting aside, the results enable us to examine whether there is support for the notion that there are multi-modal mechanisms which process *specific* emotions that might be impacted by age. An age-related deterioration in the recognition accuracy for both full-light and point-light emotional gestures was indicated. Moreover, significant dissimilarities between the age groups in vocal emotion perception were revealed in one task and a trend towards an age effect was shown in the other vocal emotion task. Combined, this suggests that the ability to perceive emotions from gestures and voices declines somewhat across the life span. Changes in emotion processing abilities with age did not extend to the facial domain. The results demonstrate that the processing of emotions by older participants from multiple communication channels varies substantially across these different tasks, and on some of the most commonly used emotion processing tasks, older adults performed well above levels predicted on the basis of previous research.

8.4.1 Gestural emotion recognition

The results on the gesture tasks contrast with work by De Meijer (1989). He asked a large group of participants to examine emotional body movements and rate these movements on scales of one to four, in terms of their emotional content. He reported no systematic differences between the older and younger raters.

The greatest differences in recognition accuracy from gestural displays in the present study are for happiness and disgust. Happiness is consistently confused with anger and the older group makes this mistake more frequently in the full-light condition (see Tables I and II, Appendix 3). Perhaps aggressive gestural happiness displays, like crowing[2], which are very symbolic, are less familiar to older participants.

[2] Crowing may be represented when the expresser's sports team has just scored a goal and they shout 'come on' and punch the air.

Consequently, older people may be more susceptible to mistaking happiness for anger, and overall, this could depress their use of the term 'happiness'.

Actors tended to represent disgust by miming wafting actions (to remove noxious odours) or faux vomiting actions. Such symbolic gestures may have become increasingly used by younger generations in the last few decades. It has been proposed that disgust may not have any conspicuous, *natural* body gestures (Coulson, 2004; De Meijer, 1989; Heberlein et al., in press). Furthermore, many of the older participants tended to describe disgust as a feeling associated with moral disgust and anger, such as disgust at a murderer or paedophile, rather than a more animal/hygiene-related disgust (Rozin et al., 2000). Since the older group did not consistently label disgusted gestures with any other particular emotion, this is indicative that the disgust displays were not compliant with older participants' concept of disgust or other emotions either. Thus, cohort and generational differences are an important consideration in the interpretation of this research.

Since age effects are revealed for gesture recognition tasks, this suggests that older individuals struggle to identify the emotions from gesture stimuli. Perhaps ageing disturbs the neural underpinnings of gestural emotion perception. Alternatively, this outcome may denote generational differences in expression, rather than recognition abilities of gestural emotion, since emotion expression, and hence recognition may be influenced by society and culture.

8.4.2 Vocal emotion recognition

Recognition of vocal emotion also seems to decline with age – although this effect is not as clear-cut as the age differences observed on the gesture tasks. Surprise from the nonsense voice task differentiates the two groups. Surprise may lack a distinct vocal profile (Banse & Scherer, 1996; Van Bezooijen et al., 1983).

Language-specific paralinguistic patterns may influence the decoding process of vocal emotion (Scherer et al., 2001). Since the nonsense word task was developed in Germany, prosody of typical German speech is varied in these vocalisations, and as all participants were British, they may have been unaccustomed to these speech patterns. In support of this idea, several researchers have reported that vocal emotion recognition, despite being universal, is improved when expression and recognition is by the same national, ethnic, or regional group (Albas, McCluskey, & Albas, 1976; Juslin & Laukka, 2003; Mesquita & Frijda, 1992). Moreover, in-group advantage is highest for happiness (Elfenbein & Ambady, 2002). Thus, one would predict an out-group disadvantage for happiness, which was found in the present study. The use of German stimuli may have rendered happiness perception vulnerable to age effects.

Due to widespread media exposure and ease of travel available to younger generations, it is proposed that younger people might be more familiar with emotional displays by people from other cultures than perhaps older people. This would result in a better interpretation of vocal emotions by the younger group, or in a resistance to cross-cultural vocal perception effects.

8.4.3 Facial emotion recognition

While consistent deficits in interpreting facial emotion have been reported by other studies in older populations, most specifically in the recognition of negative emotions, it comes as a surprise that the current study does not replicate this effect. Indeed, even when the population is divided further, by comparing the very oldest participants with the very youngest, there are still no signs of decline or improvement with age in facial emotion recognition.

The results from the Ekman 60 face perception task are not near ceiling or floor levels, except happiness, so general performance level cannot explain the lack of age group differences. Moreover, both face tasks have been used in previous studies that have detected an effect of age (Calder et al., 2003; MacPherson et al., 2002; Moreno et al., 1993; Phillips, MacLean et al., 2002). It is credible that cohort differences could be central to these findings. For instance, many research studies recruit participants through volunteer panels; however, the current sample were selected after approaching members of the local community, such that the older community were unusually active. This cohort effect, however, would not account for impairment in the vocal or gestural tasks. It is also possible that there are no *specific* effects of ageing on emotion processing.

A parsimonious explanation for this finding might be that since a wide range of tasks all focusing on emotions were administered in this experiment, participants became highly sensitive to emotional displays. The order remained constant, and so participants always completed the facial recognition tasks after the gestural and vocal tasks. This could explain the results. In other words, the participants may have become primed towards emotion stimuli, and as such, facial expression discrimination improved across the board. Affective priming paradigms have been implemented within psychological research to show that prior emotional stimuli presentation can lead to heightened sensitivity to subsequent, and usually, congruent emotional stimuli. This sensitivity may be characterised by faster response speeds, increased categorisation accuracy and so on. For a detailed review of affective priming, please refer to Musch and Klauer (2003).

8.4.4 Potential impact of traits or states

As mentioned earlier, older individuals are reported to be happier and more in control of their emotions than younger individuals (Lawton, 2001; Lawton et al., 1992). Interestingly, the older people had a greater tendency than younger people to use the label 'sadness' on both of the gestural and both of the vocal tasks (see Tables I-VIII, Appendix 3). This could reflect overcompensation for their decreased experience of negative emotions: the older participants might have been impaired in their ability to recognise negative emotions, and thus, used the 'sadness' label as a generic negative label. This pattern contrasts with previous reports of a sadness recognition deficit in older people, however (Calder et al., 2003; Moreno et al., 1993; Phillips, MacLean et al., 2002; Sullivan & Ruffman, 2004a). Furthermore, the younger group generally use the label 'happiness' more often on both of the gesture, and one of the vocal tasks, and also this group are more likely to accurately identify happy stimuli. This does not sit well with the demonstration in Chapters 3, 4, and 5, and past literature, that mood congruence may be displayed in emotion perception results (Niedenthal & Dalle, 2001; Niedenthal et al., 2000; Niedenthal et al., 1997; Niedenthal & Setterland, 1994).

Since social interactions are considered to elicit and expose people to emotions (Levenson & Gottman, 1983), a decline in social involvement, which is often associated with the elderly (Carstensen, 1987), may further inhibit abilities to accurately decode others' emotional expressions. Thus, general deterioration in emotion recognition accuracy for voices and gestures, as observed in the current study, would be consistent with this. The social nature of emotion renders it a likely candidate for the deleterious effects of ageing.

8.4.5 Correspondence with the neuroscience literature

There is no clear pattern of emotion perception decline in older adults across or within modalities. For instance, an emotion may be selectively disrupted in a given task (e.g. full-light gestural sadness), but this disproportionate decline in performance is not replicated in other tasks within that modality or in any other communication channel. From a neuropsychological point of view, this suggests that ageing does not affect neural mechanisms that process specific emotions. Task specificity in recognition impairments could indicate that separable neural substrates may be responsible for processing emotions in each task. Such an arrangement is possible given that biological systems have evolved under constraints so neural systems may not show the simplest organisation. This is not, however, a parsimonious account of emotion perception or the impact of ageing.

This brings under scrutiny the view that each emotion has an associated neural circuitry, independent of other emotion circuitry. For instance, it has been proposed that perception of fear and disgust are subserved by discrete neural substrates, with the amygdala associated with general fear processing, and the basal ganglia and anterior insula are related to disgust processing (Calder et al., 2001). See Section 1.5.2 for further details. If support for these concepts were to be provided by the present results, the decline in performance for the perception of a specific emotion shown on one emotion task by a group would be expected to extend to other tasks depicting the same emotion, involving a variety of forms of expression. Some recognition studies using vocal and facial depiction of emotions have reported common deficits (Adolphs et al., 2003; Calder, Keane, Manes et al., 2000; Scott et al., 1997; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 1999) but most other studies test only one modality. As a consequence, the current findings challenge the generalisation of the conclusions of selectivity of emotional impact in studies that have examined only one channel of communication (see Section 1.5.2 for a fuller account).

At this point in the thesis, it is worth briefly describing research that is less consistent with a theory of selective neural mechanisms for distinct emotions. Speculation is derived from a wide range of imaging and neuropsychological studies (see Section 1.5.3). For example, activity of the amygdala changes in response to the presentation of sadness, happiness, anger, as well as fear-related stimuli (Blair et al., 1999; Breiter et al., 1996; Morris, Friston et al., 1998; Sander et al., 2003; Sander & Scheich, 2001; Whalen et al., 1998; Winston et al., 2003).

Neuropsychological research often does not provide evidence for clear dissociations in emotion processing either. While fear may be the most severely disrupted emotion, patients with amygdala damage appear to be impaired in interpreting anger, disgust, and also sadness and surprise to some extent (Adolphs et al., 1994; Adolphs et al., 1995; Anderson & Phelps, 1998; Broks et al., 1998; Calder, Young, Rowland et al., 1996; Rapcsak et al., 2000).

Huntington's and Parkinson's disease have their pathology rooted in basal ganglia dysfunction, which seems to be related to deficits in disgust processing (Gray et al., 1997; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 2003; Sprengelmeyer, Young, Sprengelmeyer et al., 1997); however, most negative emotions are interpreted with difficulty by this population (Milders et al., 2003; Sprengelmeyer et al., 1996). There is also evidence for a marked impairment in fear processing in Parkinson's sufferers (Sprengelmeyer et al., 2003). Please refer to Section 1.5.3 for more information.

Furthermore, Kan and collaborators (2002) revealed that Parkinson's disease patients were significantly worse than healthy participants in their perception of fear and disgust facial expressions, but deficits did not extend to prosodic or written stimuli. This dissociation indicates that the neural substrates implicated in emotion processing may not be the same for a specific emotion expressed in different channels.

The clearest case for modularity is the anterior insula cortex involvement in processing of disgust (Adolphs et al., 2003; Calder, Keane, Manes et al., 2000). The basal ganglia and insula cortex are more involved in processing of facial disgust (Phillips, Young et al., 1998; Sprengelmeyer et al., 1998), but the basal ganglia also respond to the presentations of happy-related stimuli (Phan et al., 2002). Moreover, not all studies find insula activity to facial disgust (Heining, 2003), and some studies find anterior insula activity evoked by emotions other than disgust (Morris, Scott et al., 1999). So perhaps the strongest claim for emotion selectivity which can be made is that the insula cortex is disproportionately but not exclusively involved in the processing of disgust.

It seems that the primary criteria for a particular brain region to be a modular system, processing exclusively one emotion, are not clearly met in the literature. On the basis of established literature, it is plausible that particular neural regions may be disproportionately involved in the processing of specific emotions. With respect to ageing particularly, however, one cannot conclude that there is deterioration of emotion specific modules of processing. Ageing impacts particular brain systems – but it has diffuse effects; so ageing is perhaps not the ideal basis for revealing multi-modal selective disturbance in emotion recognition.

An alternative neuropsychological explanation of the current results concerns the fact that the facial tasks, used in this and the great majority of other studies, are behaviourally dissociable from gestural and vocal tasks, since they involved static representations of emotion. Both gesture and vocal tasks can be considered dynamic, and subsequently, it is plausible that the neural mechanisms involved in the processing of dynamic information deteriorate faster with age.

Given the association between temporal and frontal regions with ageing, it is of interest that the right temporal lobe and the prefrontal cortex have been implicated in prosody perception (Mitchell, Elliott, Barry, Cruttenden, & Woodruff, 2003; Wildgruber, Pihan, Ackermann, Erb, & Grodd, 2002). Furthermore, human neuroimaging experiments have demonstrated activation of regions within the superior temporal sulcus in response to hearing human vocal information (Belin et al., 2004; Belin et al., 2000; Gervais et al., 2004), seeing speech (Calvert & Campbell, 2003), viewing body movements (Allison et al., 2000; Bonda et al., 1996; Grossman et al., 2000; Howard et al., 1996; Puce & Perrett, 2003), and perhaps even to actions and intentions inferred from stories (Saxe & Kanwisher, 2003). The superior temporal sulcus has strong connections with the amygdala (Aggleton, Burton, & Passingham, 1980). Since structures of the temporal lobe have been implicated in the neuropathology of ageing, this region may be a candidate where degeneration disrupts processing of dynamic signals, and hence, degeneration disrupts recognition of gestural and vocal emotion.

This proposal may go some way towards explaining the current findings, but it is unclear why other studies have produced facial emotion perception results that are inconsistent with the present study.

8.4.6 Alternative explanations

Patients suffering from dysphasia and anomia suffer a drastic decay in the comprehension and generation of more unusual semantic categories, but regular and well-practised abilities were relatively preserved (Hodges, Patterson, Oxbury, & Funnell, 1992). A 'first-in, last-out' principle was proposed as a consequence of such research. Thus, for emotion processing, it is plausible that the easier the emotion is to perceive from a particular channel, the more likely perception from this channel will be maintained with age. Since the perception of cues from channels in which an emotion is least well expressed may not occur very often, comprehension may decline with disuse. Disuse, along with disease, are chief reasons for neurological deterioration associated with ageing (Zec, 1995).

Some emotions may be better recognised from one channel as opposed to another, perhaps due to the way signalling systems have evolved for conveying those emotions. This might not always be through facial expressions, which work only in close proximity. Observers tend to be more receptive and attuned to information presented by the particular channel that is most relevant for communication of that emotion (Gibson, 1979). For instance, disgust may be better conveyed by the face than by body movements or voices, since, as reported earlier, disgust is believed to have evolved as a warning to prevent ingestion potentially noxious substances (Rozin et al., 2000) and oral cues should be best communicated via the face. See Chapter 10 for more information.

8.4.7 Conclusions

In summary, there is no clearly defined pattern of emotion perception decline in older adults. In comparison with a younger group, older people were less accurate in recognising emotions from gestural cues (which involve body movements). This deterioration is worse for disgust and happiness; however, recognition for the younger participants was worst for these emotions too. The older group tend to be less accurate in perceiving vocal emotions. The present study has demonstrated that there is, at least, one population group in which facial emotion recognition abilities are not impacted by age. It is possible that ageing effects on emotion perception reflect cognitive loss of those recognition skills that are less defined in early adulthood. Alternatively, it is posited that each emotion may be communicated most easily through one or two particular channels, faces for proximate communication and gestures and voices for distal communication. This may determine which emotional expressions are least affected by any decline in ageing.

The lack of consistency in the present results provides an argument against the concept of neural specificity for emotion processing. Since no age-related deficits for particular emotions were revealed that extend across communication channels, this might indicate that distinct neural mechanisms for emotion processing do not exist or are not affected by ageing. The results raise questions concerning the methods used to explore dissociable emotion perception mechanisms and their interpretation.

Substantial replication will enable discussion of such findings in the context of the differential effects of ageing. Extensive research will need to explore these ideas further. In the meantime, it is suggested that researchers explore performance on several emotional tasks rather than restricting conclusions to one modality only.

9 EMOTION RECOGNITION IN PARKINSON'S DISEASE

Existing research concerning the influence of Parkinson's disease on emotion recognition abilities is inconsistent. This study will examine whether neural systems affected by Parkinson's disease can be associated with changes in the recognition of emotions. In turn, the research will also investigate whether the processing of the same emotions portrayed in multiple communication channels is impaired. Moreover, since the primary symptom of deficit in Parkinson's disease is motor control, a proposed relationship between expression and recognition in emotional communication suggests that Parkinson's disease might disproportionately affect recognition of dynamic signals of emotions.

9.1 Parkinson's disease: a background

9.1.1 Introduction to Parkinson's disease

Parkinson's disease or *paralysis agitans* is a progressive neurodegenerative motor control disorder (Hoehn & Yahr, 1967; Pearce, 1995), which affects around 120 000 people in the United Kingdom. More men are diagnosed than women. Its onset is commonly late-middle age, typically sixty years or more. The most prominent of the disease's physical symptoms is manifest initially as a pronounced **tremor** affecting the extremities: usually the hands, feet, chin, or lips. Stiffness and slowness of movement, characterised in a shuffling walk and stooped posture, also develop. Consequently, patients have difficulty initiating and executing movements or turning. Voluntary movement is slow and has reduced amplitude. This slowed movement that is known as **bradykinesia**. Fine movements become problematic. This is resultant in a diminished number of spontaneous movements (**hypokinesia**). Bradykinesia is independent of rigidity. **Rigidity** is apparent when muscle tone increases: limbs are resistant to passive movements. This can start in the neck and shoulders, and is more prominent there than the arms and legs. Abnormal posture or gait is adopted due to the rigidity. Balance can be difficult. Of more relevance to the present study, blank facial expressions and a soft, hoarse voice with a lack of inflection are also some of the early symptoms. For more information regarding physical symptoms and their onset, please refer to Hoehn and Yahr (1967).

Parkinson's disease is also associated with psychiatric problems. Depression can occur at any stage of the disease, it may even precede the motor symptoms. Depression affects one third to half of all Parkinson's sufferers (McDonald et al., 2003; Pearce, 1995; Rojo et al., 2003). Depression has been associated with neuroanatomical degeneration rather than a reaction to psychosocial stress and disability, which is often a cause of depression. As with other debilitating disorders, Parkinson's disease takes its toll on confidence and can result in a form of social phobia or anxiety disorder (Heinrichs, Hoffman, & Hofmann, 2001; Marsh, 2000; Richard, Schiffer, & Kurlan, 1996). Psychosis can also occur with Parkinson's disease. Roughly 30% of Parkinson's patients eventually develop dementia (Mohr, Mendis, & Grimes, 1995). This is most likely to occur in older Parkinson's disease patients (Hughes et al., 2000).

Milder cognitive deficits than those observed in dementia are sometimes present in Parkinson's disease, often much later in life, when such conditions are generally more rife in a typical population too. Memory is usually affected in older Parkinson's individuals (Litvan, 1999). Executive dysfunction, reasoning, problem-solving and visuo-spatial impairments are regularly recorded (Mohr et al., 1995). Selective attention and strategy are likely to be affected. Cognitive deficits associated with both Parkinson's disease and normal ageing, however, seem to be modulated by dopamine levels in the brain (Kaasinen & Rinne, 2002).

9.1.2 Pathological features

Parkinson's disease is associated with basal ganglia dysfunction. Early pathology is characterised by progressive degeneration of cell bodies and loss of pigmented dopaminergic neurons, which project to the striatal complex (putamen and caudate nucleus) from the substantia nigra in the midbrain (Greenfield, Adams, & Duchen, 1992). This region is known as the nigrostriatal tract. A deficiency in dopamine in the striatum, especially of the putamen follows. When around 60% of nigral neurons are lost and there is roughly an 80% depletion of striatal dopamine, the motor symptoms of Parkinson's disease symptoms begin to emerge. Dopamine loss is also recorded in the global pallidus and the hypothalamus, although these are not considered to be the cause of the main Parkinson's disease symptoms. It should be noted, however, that dopamine levels in the brain, particularly in the basal ganglia, do decline with normal ageing (Carlsson & Winblad, 1976). For more information regarding the neurophysiological changes observed in Parkinson's disease and the functional architecture of basal ganglia circuits, please refer to Valls-Solé and Valldeoriola (2002), Kaasinen and Rinne (2002), Alexander and Crutcher (1990), and Parent and Hazrati (1995). Dysfunction and deterioration of the amygdala complex (Harding, Stimson, Henderson, & Halliday, 2002; Mattila, Rinne, Helenius, & Roytta, 1999; Ouchi et al., 1999) and the orbitofrontal cortex (Freedman, 1990; Ouchi et al., 1999) have also been associated with Parkinson's disease.

9.2 Introduction to the study

9.2.1 Emotion processing in Parkinson's disease

The orbitofrontal cortex (Blair et al., 1999; Hornak et al., 1996), amygdala, and basal ganglia have been associated with emotion processing, particularly from facial expressions (see Section 1.5.2). The dopaminergic system has also been implicated in anger perception (Lawrence, Calder, McGowan, & Grasby, 2002). Atypical emotion processing might accompany Parkinson's, since this illness has an impact on these neural regions. Scott and colleagues (1984) reported that Parkinson's patients, in comparison to control participants, had considerable difficulties matching emotional prosodic phrases to emotional faces depicted in cartoons – whether this reflected a problem in vocal emotion perception or facial emotion perception was unclear. The present study seeks to relate disturbed emotion perception abilities to dysfunction associated with Parkinson's disease.

9.2.1a Facial expressions of emotion

A reduced ability to express posed and spontaneous facial emotion is observed in Parkinson's disease (Borod et al., 1990; Gelb, Oliver, & Gilman, 1999; Jacobs et al., 1995; Katsikitis & Pilowsky, 1991; Madeley, Ellis, & Mindham, 1995; Simons, Ellgring, & Pasqualini, 2003; Smith, Smith, & Ellgring, 1996). This difficulty (known as hypomimia) is one of the diagnostic criteria outlined by the Hoehn and Yahr scale (1967), and may be based on Parkinson's disease patients' movement difficulties, or alternatively, it may reflect a more general emotional impairment.

9.2.1b Facial emotion recognition

Dewick and colleagues (1991) reported that emotional memory for familiar and unfamiliar faces is affected by Parkinson's disease, but not facial emotion perception. Furthermore, Madeley and colleagues (1995), despite reporting a deficit in *expressing* facial emotion, did not find that Parkinson's disease patients were impaired in *comprehending* facial expressions of others. In accordance, Adolphs and colleagues (1998) also reported that Parkinson's disease patients did not demonstrate a deficit in emotion perception. Adolphs and colleagues' study can be criticised for the fact that medication and illness duration were not controlled. Medication may alleviate difficulties in emotion processing.

In contrast, Blonder and colleagues (1989) and Jacobs and collaborators (1995) have reported that people suffering from Parkinson's disease have general deficits recognising facial expressions of emotion, in comparison to healthy control participants. Dujardin and co-workers (2004) also observed a general deficit for rating the *intensity* of emotions depicted in facial expressions.

Some studies have identified specific emotions which are particularly difficult for Parkinson's disease patients to interpret from facial cues. Kan and colleagues (2002) observed that Parkinson's disease was associated with a significant impairment in recognising facial fear and disgust.

Sprengelmeyer and colleagues (2003) also found that unmedicated Parkinson's patients had particular difficulties in recognising facial disgust, and to a lesser degree facial expressions of anger, in comparison to control participants and medicated Parkinson's patients. Consequently, Sprengelmeyer and his collaborators argued that brain regions, such as the 'limbic loop' structures, which are modulated by dopaminergic neurons, are involved in the processing of disgust. They also noted that Parkinson's patients, whether medicated or not, showed a significant deficit in recognising fear from faces, in contrast with control participants. This may reflect an exacerbation of task difficulty in the patients, such that normal participants also found fear problematic to interpret from facial stimuli. This research concurs with Kan and colleagues' aforementioned study.

9.2.1c Vocal emotion expression and recognition

Prosody refers to features of speech such as emphasis or stress on particular syllables, differences in tempo or timing, and changes in pitch and intonation. Emotional dysprosody pertains to the inability to use these prosodic inflections or variations to convey emotion in speech. This is another clinical feature of Parkinson's disease (Caekebeke, Jennekensschinkel, Vanderlinden, Buruma, & Roos, 1991; Darkins, Fromkin, & Benson, 1988; Hoehn & Yahr, 1967; Pell & Leonard, 2003; Scott & Caird, 1983). Emotional dysprosody, in the case of Parkinson's, could be attributable to a motor deficit, independent of the patients' mental or affective status (Critchley, 1981), such as an akinesia-induced mechanical impairment of the vocal folds. Alternatively, as with facial expression difficulties, it could also represent a wider dysfunction of the neural substrates for emotion.

Some studies report a reduced ability to recognise vocal emotions by Parkinson's disease patients (Lloyd, 1999; Pell, 1996), which may be concurrent with a difficulty in expressing them (Blonder et al., 1989). This deficit in perception is independent of any acoustic processing problem (Breitenstein, Van Lancker, Daum, & Waters, 2001). A dissociation might exist between production and recognition of vocal emotion in Parkinson's disease, in which production is affected but not recognition (Benke, Bösch, & Andree, 1998; Caekebeke et al., 1991; Darkins et al., 1988).

Subcortical brain structures implicated in Parkinson's disease have been linked to prosodic expression and recognition deficits. For example, neuropsychological studies have revealed that the cingulate gyrus, which receives dopaminergic projections from the substantia nigra, may be involved in understanding prosody (Jurgens & Muller-Preuss, 1977; Jurgens & Von Cramon, 1982). The thalamus has been associated with the integration of expression and recognition of vocal information (Bell, 1968; Damasio, Damasio, Rizzo, Varney, & Gersh, 1982; Quaglieri & Celesia, 1977). Effective vocal expression has been linked to recruitment of the basal ganglia and anterior insula (Cancelliere & Kertesz, 1990; Starkstein, Federoff, Price, Leiguarda, & Robinson, 1994); by contrast, the premotor cortex is activated when Parkinson's disease patients express themselves vocally (Liotti et al., 2003).

To summarise, dysprosody observed in Parkinson's disease appears to encompass expressive, and potentially, receptive components of emotional processing. These difficulties have been associated with dysfunction of the basal ganglia, insula, and thalamus.

9.2.1d A multi-component approach

A few studies have examined emotion processing in Parkinson's disease from a number of communication channels. Kan and colleagues (2002) observed that Parkinson's sufferers exhibited impairments in recognising facial disgust and fear, but not in recognising emotion from vocal or written cues. This led the authors to conclude that the basal ganglia are important for processing visually presented emotions only. Moreover, Borod and collaborators (1990) compared and contrasted a number of clinical populations in their expression *and* recognition of emotion through facial *and* vocal channels. Facial and vocal expression abilities were impaired in Parkinson's patients, in comparison to normal, control participants. The Parkinson's group also showed a deficit in vocal emotion recognition. Facial expression recognition was within the normal range, however. This is contrary to research cited earlier.

Yip and co-workers (2003) reported that patients with bilateral Parkinson's disease showed a general deficit in recognition and discrimination accuracy for both facial and vocal stimuli, in comparison to healthy individuals and patients suffering from right-sided Parkinson's disease. Overall, fear processing was most impaired. The patients with unilateral Parkinson's disease had impairments on both recognition tasks, and this was worst for disgust and sadness. The study did not explore each emotion in the different expression channels separately, so it is unclear whether the deficits are present for fear, disgust, and sadness recognition in *both* facial and vocal channels.

Research exploring emotional communication in Parkinson's disease lacks consistency. The impact of Parkinson's disease on emotional communication abilities therefore remains unresolved. Deficits may be confined to speech production, facial expression production, production of emotion in general; or they may be part of a more general impairment in emotion processing, encompassing emotion recognition abilities. Methodological issues could be the foundation for these discrepancies. Thus, this chapter seeks to resolve the conflict, and to establish whether a pattern of impairments, specific or general, does exist, using a comprehensive set of tests that involve emotional communication by faces, voices, and gestures.

9.2.2 Restricted biological motion and its perception

Perception and production of biological movement may share a common representational network and could explain receptive and expressive deficits in Parkinson's disease. Mirror neurons are activated when a participant executes an action, and during observation of that same action being performed by someone else

(Rizzolatti et al., 2001). It has been proposed that a network of mirror neurons, involving somatosensory cortices, may play a role in perceiving or inferring the mental states of others by mapping their expressions onto a mental representation of our own expressions (Adolphs et al., 2000; Heberlein et al., in press; Kohler et al., 2002). This would aid recognition and interpretation of others' intentions and feelings. See Section 1.5.4 for more information.

Being touched and seeing someone else being touched activate the somatosensory cortices (Keysers et al., 2004). Furthermore, seeing someone experience disgust and being exposed to a disgusting smell both activate the anterior insula (Wicker et al., 2003). The anterior insula contains visceral somatosensory cortex and is heavily interconnected with the basal ganglia. These studies provide support for the role of mirror neurons in empathy and the perception of social states of others. Right somatosensory cortex is crucial for the processing of facial emotion, as shown from lesion analysis research (Adolphs et al., 2000) and research using Positron Emission Tomography (Kilts, Egan, Gideon, Faber, & Hoffman, 1996). These researchers propose that recognising static facial emotion requires implicit imagery of the motor patterns of each facial expression, in order to match a static percept with these motor images.

In support of this premise, *imagining* actions, as well as executing and observing them, also activates mirror neurons in the premotor cortex (Decety & Chaminade, 2003; Deiber et al., 1998; Lotze et al., 1999). Jeannerod (1994; 1995) and Decety (1996) suggest motor imagery involves conscious motor representations, which involve the same preparatory processes as actual movements; yet execution of such movements is suppressed. Consequently, execution and perception of actions may rely on intact mental imagery. Parkinson's sufferers, while having problems in motor control, also have abnormal patterns of neural activation during generation of motor imagery (Filippi et al., 2001; Thobois et al., 2000). Moreover, activation is abnormal when Parkinson's sufferers imagine *and* perform movements (Thobois et al., 2002). The translation of motor representations into motor actions is impaired in this population too (Yágüez, Canavan, Lange, & Hömberg, 1999). Performance on facial imagery tasks are impaired in Parkinson's disease: patients are less accurate than control participants in imagining a target facial expression and answering questions about it (Jacobs et al., 1995). Possibly, Parkinson's disease patients might have difficulty in recognising expressions because of problems associated with motor imagery and motor control.

Restrictions to body movement and postures in healthy individuals do not seem to influence action simulation for others (Fischer, 2003, in press). Sufferers from Möbius Syndrome, a congenital disorder that results in facial paralysis, can easily recognise facial expressions of emotion in others, despite their restricted ability to produce these expressions themselves (Calder, Keane, Cole, Campbell, & Young, 2000). The conditions leading to movement restriction in this disorder may involve peripheral motor neuron or nerve damage, rather than central control of movement production, unlike Parkinson's disease. Thus, neural circuits for perception and production of biological motion may be impaired in Parkinson's disease.

9.2.3 Current study

A set of emotion perception tests was selected to explore emotion recognition in Parkinson's disease. These tests include a static facial expression recognition task, a verbal vocal expression recognition task, and a full-light dynamic gesture expression recognition task.

9.3 Phase 1 method

Ethical approval

This study was approved by the Lothian Research Ethics Committee, the Wellcome Trust Clinical Research Facility, the Research and Development Management Trust for Lothian, and also by the University of St Andrews, School of Psychology Ethics Committee.

Facilities

Testing with patients took place in a consultation room within the Wellcome Trust Clinical Research Facility, Western General Hospital, Edinburgh. The Facility is designed for research purposes. Similar facilities were arranged for control participants at the University of St Andrews, or in their homes.

9.3.1 Participants

9.3.1a Parkinson's disease participants

Eight people (three male, five female), with a diagnosis of idiopathic Parkinson's disease made by a neurologist, gave their informed consent to participate in the study. Participants were contacted initially by their consultant neurologist (please see Appendix 5).

All participants had been diagnosed with Parkinson's disease between 1 and 5 years ago. Mean symptom severity was equivalent to Hoehn-Yahr 2, ranging from 1-3 (Hoehn & Yahr, 1967). Severity of symptoms, as well as demographic information, background neuropsychological information, and medication details are given in Tables I and II in Appendix 6. None of the patients had dementia as determined by a neurologist's assessment. None of the patients were currently suffering from any diagnosed clinical mood disorder. One patient, despite being classed as suffering *moderate* depression, according to her score on the Beck Depression Inventory, was not subsequently diagnosed with depression. The mean age of the participants was 56.38 (s.d. 6.39). Mean Full-Scale IQ was 118.13 (s.d. 5.84), as calculated using the NART[3] (Nelson & Willison, 1991).

Medication: Seven of the patients were receiving dopamine agonist medication. Three of these patients were also receiving a levodopa/carbidopa combination. One patient was not taking any prescribed drugs. See Table II in Appendix 6.

[3] NART is shown in Appendix 1

9.3.1b Control participants

The control group consisted of sixteen normal, healthy adults (six males, ten females) with no history of neurological or psychiatric illness. Control participants and Parkinson's disease patients were matched (two control participants per patient) on age (control group, 57.38 ± 6.06; Parkinson's disease group, 56.38 ± 6.39 years), years of education (control group, 15.25 ± 2.82; Parkinson's disease group, 13.88 ± 3.60), and IQ (control group, 118.31 ± 4.99; Parkinson's disease group, 118.13 ± 5.84). A between-subjects ANOVA revealed that there were no significant differences in these scores: age, $F_{(1,23)} = 0.140, p=0.712$; years of education, $F_{(1,23)} = 1.057, p=0.315$; IQ, $F_{(1,23)} = 0.037, p=0.849$. All participants gave informed consent to participate in these research studies.

9.3.2 Background tasks

Tests were employed to examine the participants' emotional experience of fear and disgust, in order to investigate whether this is within the normal range. An emotion definition test was also employed to ensure the participants had a basic concept of the meaning of each emotion

9.3.2a Stimuli

Wolpe and Lang's (1964) fear schedule and Haidt and colleagues' (1994) disgust questionnaire were administered. Since Parkinson's disease is often associated with depression, and negative moods have been associated with difficulties in perceiving disgust (see Chapters 3, 4, and 5), the Beck Depression Inventory (Beck & Steer, 1987) was given to the Parkinson's disease patients. Please see Appendix 1 for full versions of each of these questionnaires.

9.3.2b Procedure

After the experimental tasks, participants were given the disgust questionnaire first, followed by the fear questionnaire, and the depression questionnaire. Participants could take as long as they wished to complete these questionnaires.

9.3.3 Experimental tasks

Due to time constraints, the likelihood of holding patients' attention, and respecting their co-operation, only one test from each of the facial, gestural, and vocal categories was implemented to assess emotion perception. The full-light gesture task was administered, followed by the verbal vocal task. The Ekman 60 faces task was then employed. See Section 2.2 for more details. The full-light gesture task was chosen, since Grèzes and Decety (2001) reported that point-light stimuli did not seem to elicit personal mental representations of observed actions.

Participants were given the NART when they had completed half of the vocal task trials. This was decided on the basis of prior testing with these stimuli (Chapter 8), when it had been noted that the vocal task was quite frustrating and difficult for participants and they welcomed a break.

9.3.4 Analysis

For all experimental tasks, a mixed-design ANOVA was carried out, with Greenhouse-Geisser corrections where necessary. The between-subjects factor was group (control, Parkinson's disease), and the within-subjects factor was recognition accuracy for each emotion (anger, disgust, fear, happiness, sadness, and surprise, where included). Significant interactions or near significant interactions or group differences were followed by independent t-tests (with equal variances assumed, where required). See Section 2.3 for more details.

9.4 Results

None of the eight Parkinson's disease patients showed severe signs of depression according to the Beck Depression Inventory (4 normal ≤4, 4 mild-moderate ≤17). All scores were within the normal to moderate range (0-20/63). There were no significant differences between the control and Parkinson's disease groups on scores for the fear questionnaire, $t(22) = 0.64$, $p=0.528$, or the disgust questionnaire, $t(22) = -0.93$, $p=0.363$.

9.4.1 Experimental tasks

9.4.1a Gesture task

The recognition accuracy rates are summarised in Figure 9.1.

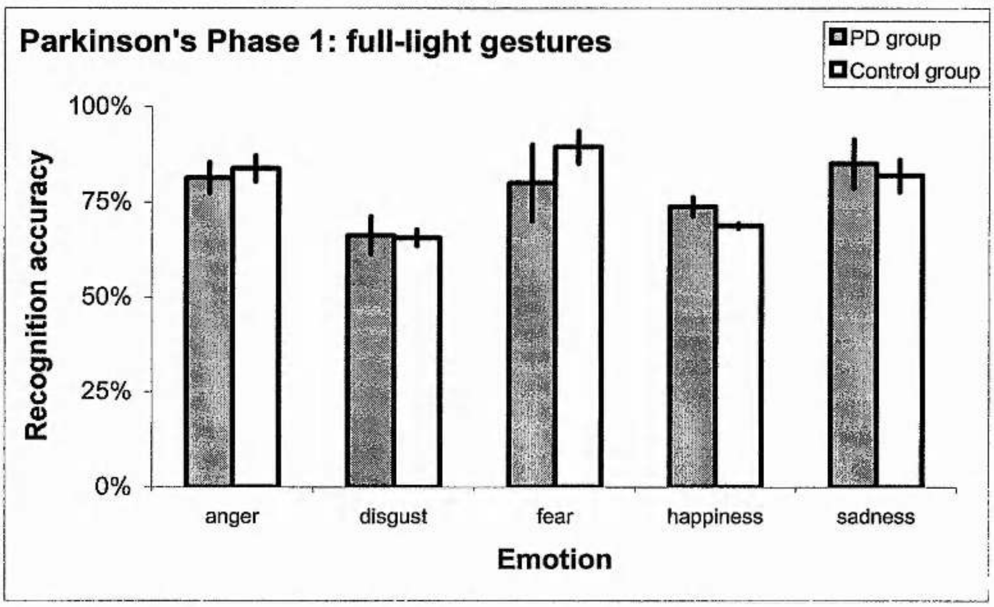


Figure 9.1: Recognition accuracy rates for full-light emotional gestures by the Parkinson's patients and by the control group.

The results revealed a significant main effect of emotion, $F_{(4,88)} = 5.66$, $p<0.001$. There was no significant difference between the two groups, $F_{(1,22)} = 0.03$, $p=0.878$. No significant interaction between emotion and group can be reported, $F_{(4,88)} = 0.63$, $p=0.640$.

9.4.1b Voice task

The results from the voice task are summarised in Figure 9.2.

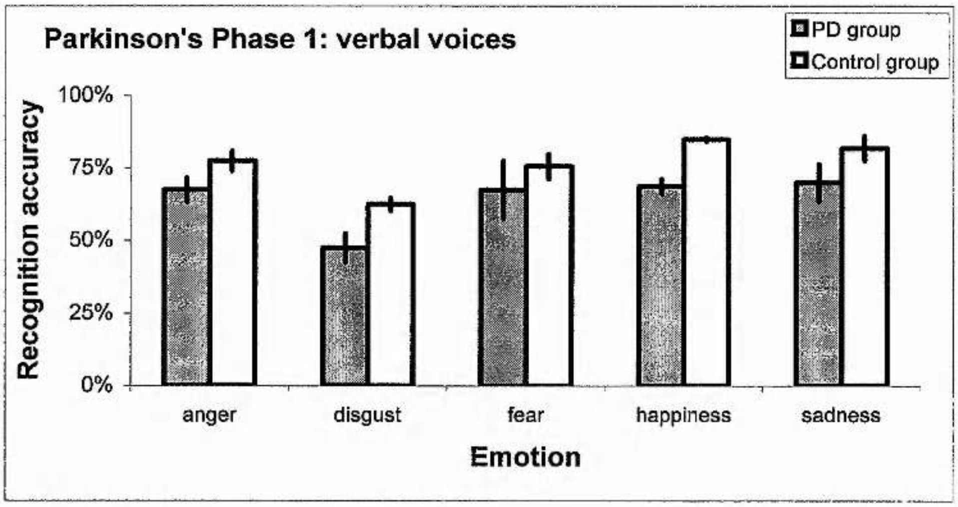


Figure 9.2: Recognition accuracy rates for the verbal voices by the Parkinson's patients and the control group.

There was a significant effect of emotion, $F_{(4,88)} = 6.67$, $p<0.001$. The Parkinson's patients were significantly less accurate on this task than the control group, $F_{(1,22)} = 5.89$, $p<0.05$. There was no emotion by group interaction, $F_{(4,88)} = 0.24$, $p=0.914$.

9.4.1c Face Task

The mean recognition rates for the emotional faces are shown in Figure 9.3.

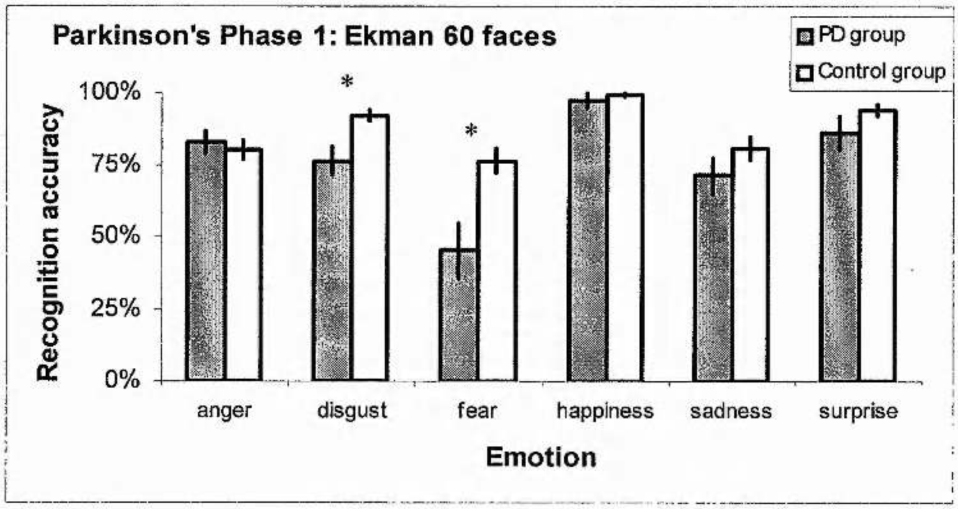


Figure 9.3: Recognition accuracy rates for the Ekman 60 faces by the Parkinson's patients and the control group.

* $p<0.05$

There was a significant effect for emotion, $F_{(5,110)} = 18.02$, $p<0.001$. There was also an effect of group, $F_{(1,22)} = 11.89$, $p<0.01$. This was further qualified by a significant interaction between emotion and group, $F_{(5,110)} = 4.26$, $p<0.005$. The patients were significantly worse than the control participants in interpreting facial fear, $t(9.64) = -2.87$, $p<0.05$, and disgust, $t(22) = -3.43$, $p<0.05$. For all other emotions, $p>0.15$.

Tables 9.1 and 9.2 show the pattern of responses made by the Parkinson's group and the control group in the facial emotion task. By examining labelling use and false positives, it is possible that further understanding of the deficits described above may be achieved.

Table 9.1: The pattern of responses to facial expressions of emotion, made by the Parkinson's group All numbers are mean percentages

		Depicted							
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Surprise**	**Total label use**	**False positives**
Perceived by the Parkinson's disease group	**Anger**	**82.5**	21.3	11.3	0.0	3.8	0.0	118.8	36.3
	Disgust	10.0	**76.3**	8.8	0.0	8.8	1.2	105.0	28.7
	Fear	2.5	2.5	**45.0**	0.0	8.8	11.3	70.0	25.0
	Happiness	0.0	0.0	0.0	**97.5**	1.3	1.3	100.0	2.5
	Sadness	0.0	0.0	5.0	0.0	**72.5**	1.2	78.7	6.2
	Surprise	5.0	0.0	30.0	2.5	5.0	**85.0**	127.5	42.5
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		17.5	23.7	55.0	2.5	27.5	15.0		

Table 9.2: The pattern of responses to facial expressions of emotion, made by the control group All numbers are mean percentages

		Depicted							
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Surprise**	**Total label use**	**False positives**
Perceived by the control group	**Anger**	**79.7**	6.8	4.7	0.0	1.2	0.3	92.6	12.9
	Disgust	10.6	**90.6**	5.0	0.0	10.3	0.9	117.3	26.7
	Fear	4.1	1.5	**70.6**	0.3	4.7	9.4	90.6	20.0
	Happiness	0.0	0.0	0.0	**99.4**	0.3	1.5	101.2	1.8
	Sadness	2.9	1.2	1.5	0.0	**80.3**	0.0	85.9	5.6
	Surprise	2.6	0.0	18.2	0.3	3.2	**87.8**	112.2	24.4
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		20.3	9.4	29.4	0.6	19.7	12.2		

In order to compare false positive use, a mixed-design ANOVA was used. Group (Parkinson's or control) was the between-subjects factor, and number of times each emotional label was used incorrectly (false positives) was the within-subjects factor (anger, disgust, fear, happiness, sadness, and surprise). To compare the responses for each emotion, a mixed-design ANOVA was administered. The between-subjects factor was group and the within-subjects factor was emotion (the percentage of incorrect responses for each non-target emotional label, or miss, when target stimuli were presented). For instance, to explore the responses made to sad faces, the number of times each group responded with the labels of anger, disgust, fear, happiness, and surprise when sad faces were represented would be compared. Independent-samples t-tests, with equal variances assumed where appropriate, followed significant interactions.

For false positive analysis, there was an effect of emotion, $F_{(2.78,\ 61.10)} = 14.49$, $p<0.001$, and group, $F_{(1,22)} = 12.23$, $p<0.005$. This was qualified by a significant emotion by group interaction, $F_{(2.78,\ 61.10)} = 2.68$, $p<0.05$. Overall, the Parkinson's group used 'surprise' to describe more facial stimuli than the control group, $t(22) = 12.23$, $p<0.005$. The Parkinson's patients also used 'anger' more often to label the facial stimuli, $t(8.25) = 3.69$, $p<0.01$. There were no significant differences between the two groups in their false positives for any other emotion, $p>0.19$.

For the labelling of disgusted faces, there was a main effect of emotion, $F_{(4,88)} = 33.69$, $p<0.001$, a main effect of group, $F_{(1,22)} = 11.78$, $p<0.005$, and a significant group by emotion interaction, $F_{(4,88)} = 9.11$, $p<0.005$. Post-hoc tests revealed that the Parkinson's patients described the disgusted faces as 'angry' more often than control participants, $t(9.47) = 2.77$, $p<0.05$. There were no other differences in labelling of disgusted faces between the groups; for all other emotions $p>0.3$.

The two groups also differed in their erroneous labelling of fearful faces. There was a main effect of emotion, $F_{(2.09,\ 45.99)} = 19.93$, $p<0.001$. A significant group effect was also revealed, $F_{(1,22)} = 11.49$, $p<0.005$. The emotion by group interaction was not significant, $F_{(2.09,\ 45.99)} = 1.61$, $p=0.211$. Post-hoc tests explored the group difference, since fear is one of the key emotions of interest following differences in recognition accuracy scores. Generally, the Parkinson's patients had a greater tendency to describe the fearful faces as 'surprised', $t(22) = 1.84$, $p=0.07$. There were no other differences in the labelling of fearful faces; for all other emotions $p>0.09$.

For anger, happiness, sadness, and surprise, the two groups did not differ significantly on types of misses, (all $p>0.16$) and no significant interactions between the groups and emotion were demonstrated (all $p>0.088$).

9.5 Discussion

The results fail to support the idea of a central impairment in the perception of a specific emotion. Parkinson's patients tested in this experiment have an apparent impairment in recognising vocal and facial expressions of emotion in comparison to healthy control participants. Parkinson's disease seems to affect most specifically the recognition of facial fear and disgust.

The results reveal a dissociation within the visual modality between processing of gestural and facial expressions emotion, since Parkinson's disease patients exhibit significantly lower accuracy levels in comparison to healthy participants only for the face task. There are several issues raised by this. First, it is possible to question whether neural pathways involved in the processing of such visual stimuli are linked. These current results suggest that there is not a general neural mechanism that processes emotions across modalities, or one that processes purely visual emotion material. The tasks are behaviourally dissociable however, so it is possible that the processing of dynamic visual stimuli is unimpaired by Parkinson's, but processing of static visual stimuli is compromised. The present study does not, therefore, provide support for the neuropsychological stance that partially independent pathways process each emotion, regardless of the communication channel in which it is presented. Nevertheless, it is possible that the brain regions involved in the processing of only *facial* fear and disgust are disturbed in Parkinson's disease.

On the other hand, since facial displays of fear are also poorly recognised in the normal population in relation to other emotions, the observed deficits in Parkinson's disease may reflect an exacerbation of difficulty observed in the normal population. That is, damage to particular brain regions in Parkinson's disease might intensify the effects of difficulty already apparent in healthy individuals. This idea is bolstered by the studies of Rapcsak and co-workers (2000) and Milders and colleagues (2003). Both of these studies report that the recognition of fear is difficult in control participants and this is intensified in clinical participants. See Section 1.5.3b for more information. Such an argument might not, however, explain the deficit for perceiving facial disgust that is exhibited in Parkinson's, since sadness recognition is characterised by lower accuracy levels than disgust in the control population.

The difficulties recognising facial fear might also be rooted in surprise perception, given that the facial expression test was the only task to include the expression of surprise. Surprise is regularly confused with fear, whereas, the reverse confusion is much less frequent (Calder et al., 2003; Rapcsak et al., 2000). For the present data set, Parkinson's patients showed a significantly greater use of surprise as a false positive than the control group. The analysis of misses demonstrates that while confusing fear for surprise is common in healthy participants, this confusion tended to be elevated in Parkinson's disease patients. As with established literature, the reverse confusion is rarely made. As recognition accuracy for fear decreases, the confusion between surprise and fear increases. Perhaps some sort of sensitivity increase in surprise perception occurs in Parkinson's disease.

A disturbance in the perception of surprise in Parkinson's disease is supported by research carried out by Dujardin and colleagues (2004). Unmedicated Parkinson's disease patients had to rate a series of facial expressions in terms of their emotional content. These faces were morphs of a neutral expression and the target emotion (anger, sadness, disgust) at either 30:70% or 70:30% proportions. For each face, participants had to indicate the intensity of component emotions (anger, disgust, fear, happiness, sadness, surprise, shame) contained in the face. The Parkinson's patients were generally impaired in comparison to control participants. Most interestingly, Parkinson's patients perceived more surprise within all emotional stimuli than the control group. This suggests that Parkinson's disease patients are particularly sensitive to surprise or demonstrate a bias to respond with the surprise label. It is plausible therefore, that Parkinson's disease disturbs surprise perception, but not necessarily fear perception. Consequently, the inclusion of surprise in the current facial task might have been instrumental in producing the differences between recognition of facial expressions and other emotion communication tasks.

As a result of the above speculation, in Phase 2 the Ekman 60 task was modified to exclude surprise, and therefore, include only 50 faces. This would also enable better comparison between the three emotion tasks, as all would contain the same five emotions. This new face test, along with the original gesture test and the original voices test, was then presented to another group of Parkinson's patients in Phase 2. Once testing was underway, it became apparent that a within-subjects comparison was desirable. Seven of the Parkinson's disease participants and fourteen of the control participants in Phase 2 were presented with both the Ekman 50 and the Ekman 60, and another facial task, with only the five emotions (excluding surprise). This was to allow an exploration of whether any changes in response patterns might be specifically attributed to the Ekman photos alone, or to the inclusion of surprise, or whether they are related to emotion perception as a whole. Should a fear deficit be manifest in Parkinson's disease populations, the exclusion of surprise should have no bearing on perception difficulties with the emotion.

9.6 Phase 2 method

9.6.1 Participants

9.6.1a Parkinson's disease participants

Twelve people (three female, nine male), with a diagnosis of idiopathic Parkinson's disease, gave their informed consent to participate in the study. Recruitment followed the same means as Phase 1.

All participants had been diagnosed with Parkinson's disease between 1 and 5 years ago. Mean symptom severity was equivalent to Hoehn-Yahr 2, ranging from 1-2.5 (Hoehn & Yahr, 1967). None of the patients had dementia as determined by a neurologist's assessment. Severity of symptoms, as well as demographic information and background neuropsychological information are given in Table I in Appendix 6. The mean age of the participants was 63.1 years (s.d. 6.04). Mean Full-Scale IQ was 115.17 (s.d. 8.17), as calculated using the NART.

None of the patients were currently suffering from any diagnosed clinical mood disorder, although one patient had suffered from a panic attack a few weeks prior to testing, which was related to anxiety as a result of her Parkinson's symptoms. Ten of the Parkinson's participants had low Beck Depression Inventory scores (Beck & Steer, 1987), experiencing normal variations in mood (score ≤ 10, out of a potential 63). One patient was classed as having borderline clinical depression (score 17-20). This was still within the moderate mood disturbance category. He had not been diagnosed with clinical depression, however.

Phase 1 and Phase 2 participants differed in age, with the group examined in Phase 2 being older, $t(18) = -2.38$, $p<0.05$. Years of education, IQ, disease severity, gender, or depression scores were no different between the Parkinson's groups, $p>0.1$.

Two of the participants used hearing aids. Both sets of data have been removed from the vocal task, to prevent confounding the results.

Medication: Eight of the patients were receiving a dopamine agonist (see Table III, Appendix 6 for details). Three of the patients were receiving levodopa/carbidopa combination (two of which were also taking a form of dopamine agonist). Two patients were not taking any medication.

9.6.1b Control participants

This control group consisted of sixteen normal, healthy adults, 6 females and 10 males, with no history of neurological or psychiatric illness. Control and Parkinson's disease participants were matched on age (controls, 62.19 ± 6.15 years; Parkinson's, 63.08 ± 6.04 years), and education (controls, 15.88 ± 3.83 years; Parkinson's, 13.17 ± 4.65 years). Between-subjects ANOVAs revealed that there were no significant differences in the scores for age and years of education (age, $F_{(1,27)} = 0.15$, $p=0.704$; years of education, $F_{(1,27)} = 2.86$, $p=0.103$), but the control participants achieved marginally higher Full-Scale IQ scores (controls, 119.88 ± 3.30; Parkinson's, 115.17 ± 8.17), $F_{(1,27)} = 4.42$, $p<0.05$. All participants gave informed consent to participate in this research study.

Control participants were within the normal range for their Beck Depression Inventory scores (mean 5.13, range 0-14). As a consequence, the two groups differed significantly in their depression scores, $F_{(1,27)} = 6.05$, $p<0.05$, but not for their depression classification, $F_{(1,27)} = 2.62$, $p=0.117$.

One male control participant did not complete the Ekman 60 faces task or the gestural task due to time constraints.

9.6.2 Tasks

The second phase of this study comprised of the same background and experimental tasks as the first phase. Two more face tasks were also presented. The Ekman 50 was identical to the Ekman 60, except it excluded surprise as a stimulus category and response choice (see Chapter 2 for more details). The other comprised ten younger actors, representing five emotions, and this task followed the same design and procedure as the Ekman 50. All tasks were computerised so that reaction times could be measured. The experimenter always pressed the buttons, in order to prevent movement difficulties influencing responses times. Ekman 50 was presented first, followed by the gesture task, vocal task, and then the alternative face task. The Ekman 60 task was given last, with the purpose of prolonging the time between the two Ekman face tasks. This design was to prevent order effects falsely boosting fear recognition rates in the Ekman 50 task.

9.7 Results

Dopaminergic medication did not correlate with any emotion recognition measures.

9.7.1 Background questionnaires

Since these questionnaires were not altered between phases of this study, results for all Parkinson's and all control participants were analysed together. Independent-samples t-tests revealed that the Parkinson's group were more sensitive to fearful and uncomfortable situations than the control group, $t(50) = 2.03$, $p<0.05$. Interestingly, scores on the fear questionnaire correlate with scores on the Beck Depression Scale, $R = 0.44$, $p<0.01$. Overall, the two groups did not differ in their disgust sensitivity, $t(50) = -0.15$, $p>0.8$.

9.7.2 Ekman 60 faces task

Of the twelve Parkinson's participants in Phase 2, only seven completed the Ekman 60 (the within-subjects comparison condition for the face tasks). Their results are combined with participants from Phase 1[4], and these are shown in Figure 9.4.

A main effect of emotion can be reported, $F_{(3.09,\ 136.01)} = 25.60$, $p<0.001$. There is also significant effect of group, $F_{(1,44)} = 18.39$, $p<0.001$. This is qualified by a significant interaction between emotion and group, $F_{(3.09,\ 136.01)} = 4.52$, $p<0.001$. Post-hoc tests revealed that Parkinson's patients had lower accuracy rates than control participants for fear, $t(44) = -3.90$, $p<0.001$, and also for disgust, $t(44) = -2.23$, $p<0.01$. For all other emotions, $p>0.16$. These results follow the same pattern as Phase 1. As an aside, sensitivity levels for disgust on this task correlated with depression scores.[5]

[4] NB. Parkinson's N=15, Control N=31.

[5] All participants who completed the Beck Depression Inventory were combined, and analysis took place to explore the proposed relationship between disgust perception and dysphoria, as described in Chapters 3, 4, and 5. Correlations revealed that the more depressed participants were, the worse their recognition of disgust in the Ekman 60 task, $R = -0.40$, N = 30, $p<0.05$, and there was a trend for difficulty in perceiving disgust in the alternative faces task, $R = -0.38$, N = 30, $p=0.07$. No other emotions or tasks correlated with Beck Depression scores, $p>0.12$.

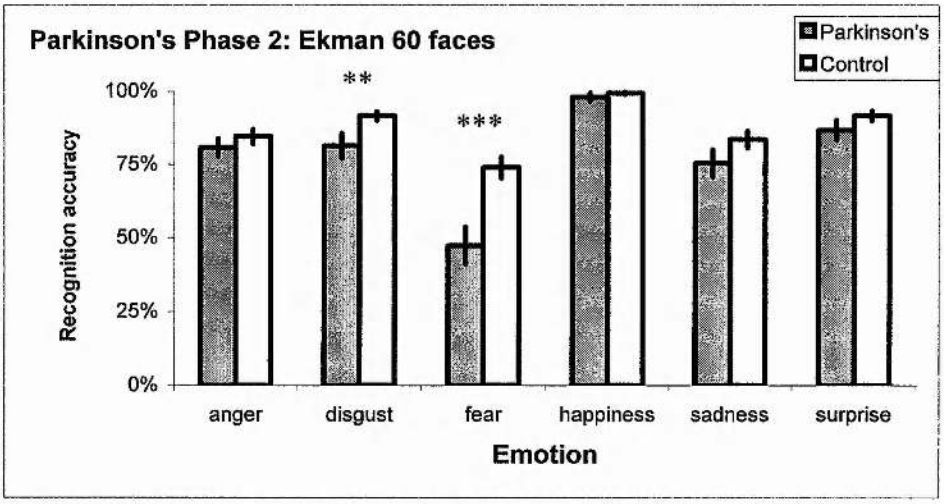


Figure 9.4: Recognition accuracy rates for emotion represented facially in the Ekman 60 task by Parkinson's participants and the control group.
** $p<0.01$ *** $p<0.001$

9.7.2a Ekman 60 faces Phase 2 participants only

The results from the Phase 2 participants[6] only were also analysed. A significant effect of emotion was revealed in this task, $F_{(2.93,58.53)} = 16.31$, $p<0.001$. No significant interaction between emotion and group can be reported, $F_{(2.93,58.53)} = 1.44$, $p=0.241$. There was an effect of group, $F_{(1,20)} = 6.251$, $p<0.05$. Post-hocs were carried out, since this task produced interesting results in Phase 1. The group difference is mainly due to a superiority by the control group to perceive fear accurately, $t(20) = -2.05$, $p=0.05$. Accuracy rates for all other emotions were not significantly different for the two groups, $p>0.086$. While this phase did not produce such a significant difference between the Parkinson's group and the control group as in Phase 1, this might be a consequence of order, as the participants completing Ekman 60 in Phase 2 had seen the Ekman fear faces in the Ekman 50 task earlier. The direction of the effects is the same for fear recognition: fear is less well recognised by the Parkinson's group.

[6] NB. Parkinson's N=7, Control N=15.

9.7.3 Gesture task

Since this task was not altered between Phase 1 and 2, all participants from each phase are grouped together for analysis[7]. The results are shown in Figure 9.5.

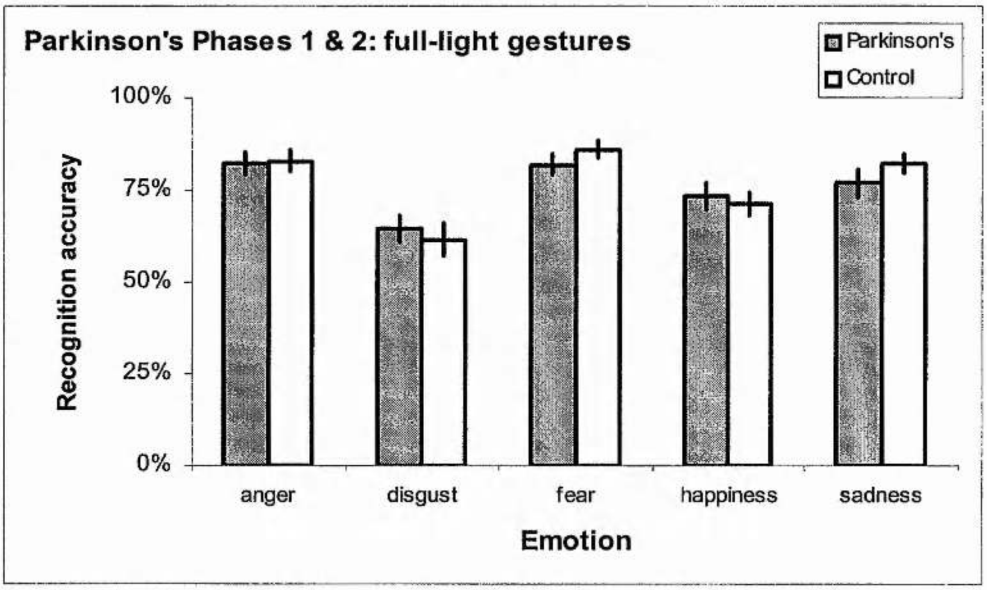


Figure 9.5: Recognition accuracy rates for emotion represented gesturally in the full-light dynamic task by Parkinson's participants and the control group.

A main effect of emotion can be reported, $F_{(4,196)} = 14.25$, $p<0.001$. There was no significant interaction between emotion and group, $F_{(4,196)} = 0.63$, $p=0.641$. There were no differences between the control group and the Parkinson's patients, $F_{(1,49)} = 0.13$, $p=0.718$.

9.7.4 Voice task

Participants from Phase 1 and 2 were combined for the analysis of the vocal task results[8]. These results are summarised in Figure 9.6.

[7] NB. Parkinson's N=20, Control N=31.
[8] NB. Parkinson's N=18, Control N=32.

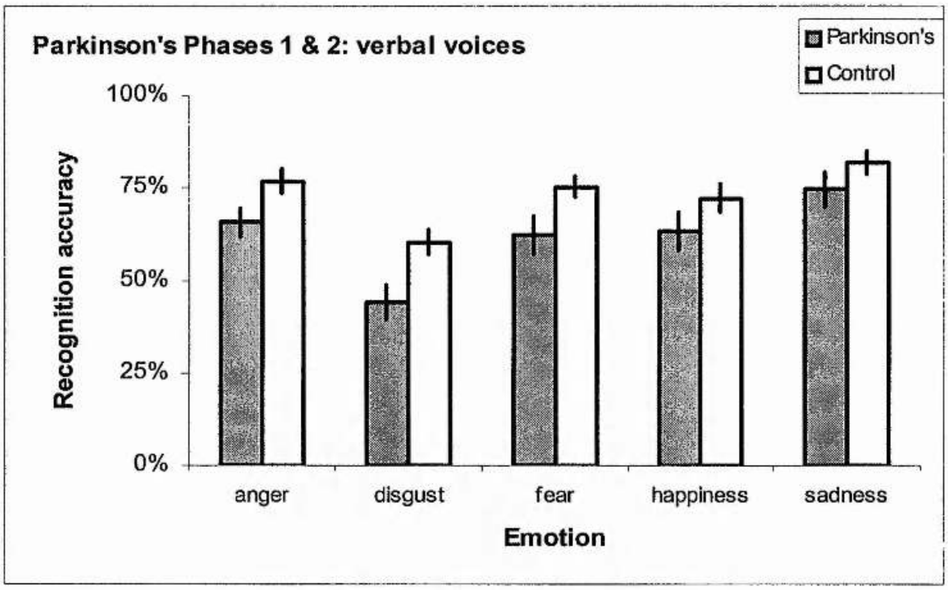


Figure 9.6: Recognition accuracy rates for emotion represented vocally in the verbal vocal task by Parkinson's participants and the control group.

There was a significant effect of emotion, $F_{(4,192)} = 16.36, p<0.001$. The emotion by group interaction was not significant, $F_{(4,192)} = 0.56, p=0.690$. The Parkinson's group attained lower accuracy rates for this vocal task than control participants, $F_{(1,48)} = 9.08, p<0.005$.

9.7.5 Ekman 50 faces task

The results for all twelve Parkinson's patients in Phase 2[9] on the adapted version of the face task, from which surprised faces and the surprise response option were excluded, are shown in Figure 9.7. A significant effect of emotion emerged, $F_{(4,104)} = 12.40$, $p<0.001$. The interaction between emotion and group was not significant, $F_{(4,104)} = 0.98$, $p=0.420$. The groups did not differ in their accuracy rate on this task, $F_{(1,26)} = 1.27$, $p=0.259$. Despite no significant interaction, fear accuracy rates were explored, since this was the emotion of interest in this task (see Section 2.3 for further rationale). The two groups did not differ in their recognition accuracy for fearful faces in this task, $t(26) = -1.05, p=0.305$.

[9] NB. Parkinson's N=12, Control N=16.

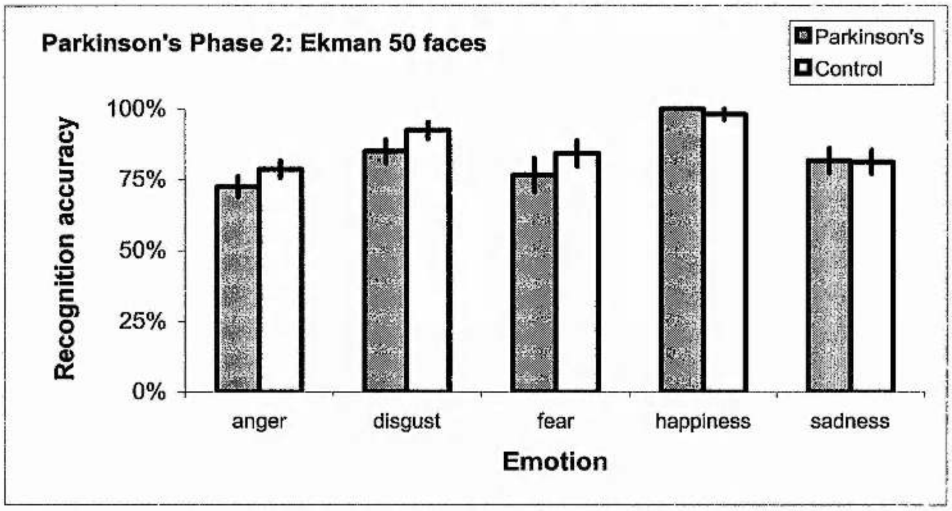


Figure 9.7: Recognition accuracy rates for emotion represented facially in the Ekman 50 task by the Parkinson's participants and control group.

9.7.6 Alternative facial expression recognition task

The results for this task[10] are shown in Figure 9.8.

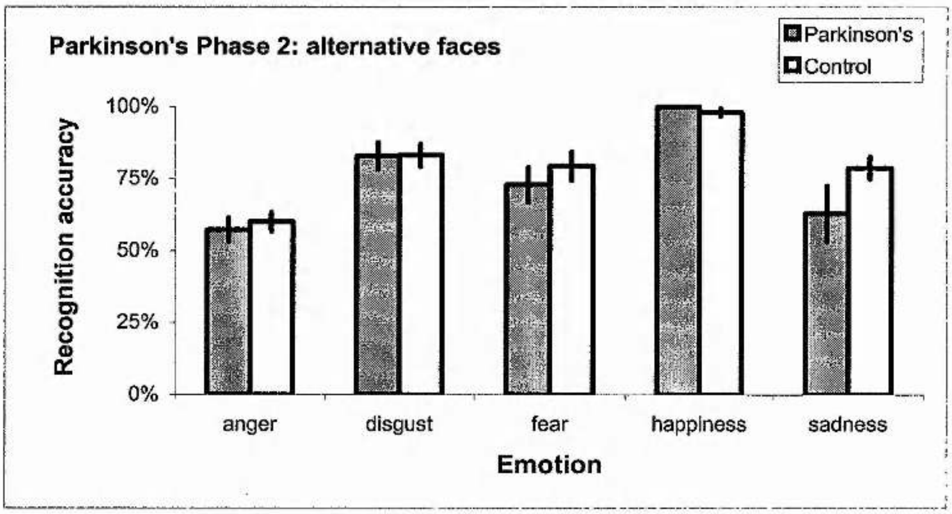


Figure 9.8: Recognition accuracy rates for emotion represented facially in the alternative task by the Parkinson's participants and control group.

[10] NB. Parkinson's N=7, Control N=16.

A main effect of emotion was revealed for this task, $F_{(4,84)} = 25.19$, $p<0.001$. An emotion by group interaction was not significant, $F_{(4,84)} = 1.36$, $p=0.254$. The groups did not differ in their recognition accuracy rates on this task, $F_{(1,21)} = 1.27$, $p=0.272$. Again, post-hoc analysis for fear was carried out, since this was the emotion of interest from the previous phase. Both groups achieved similar accuracy rates for the fearful faces, $t(21) = -0.75$, $p=0.459$.

9.7.7 Within-subjects faces comparison

The results from the within-subjects comparison condition were compared. To reiterate, seven Parkinson's patients and fifteen control participants completed both the Ekman 60 and the adapted version, the Ekman 50. The results from the two tasks are shown in Figure 9.9.

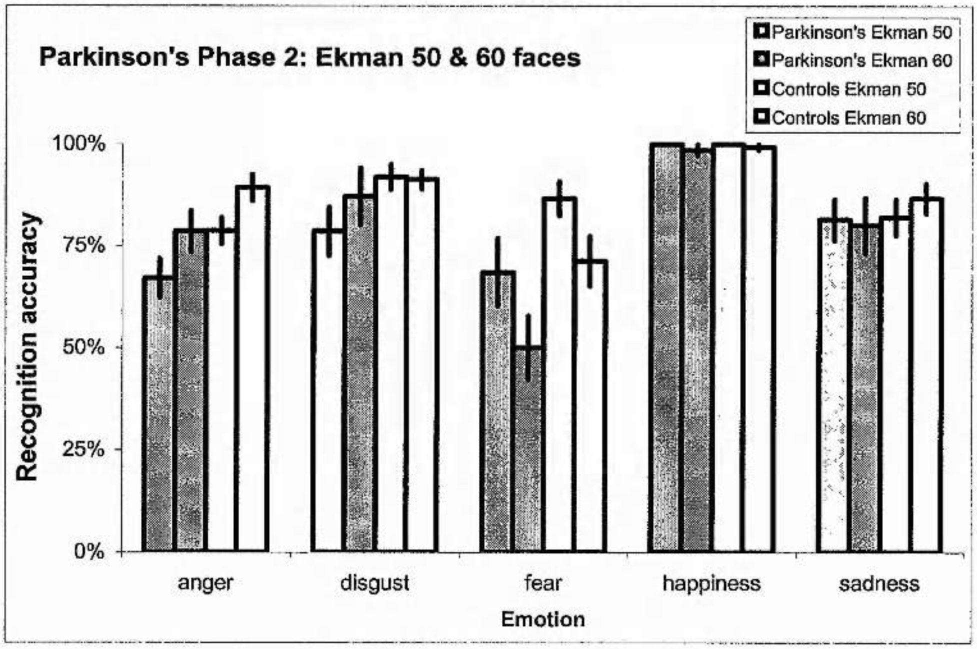


Figure 9.9: Recognition accuracy rates for the Ekman 50 and Ekman 60 tasks for only the Parkinson's and control participants who completed both tasks.

Before statistical comparison of the two tasks is reported, analysis of the Ekman 50 results for just the seven clinical participants, who completed the within-subjects comparison, in comparison to control participants is presented.

There was a main effect of emotion, $F_{(4,80)} = 13.81$, $p<0.001$. The interaction between emotion and group was not significant, $F_{(4,80)} = 2.30$, $p=0.079$. There was a borderline effect of group, $F_{(1,20)} = 4.00$, $p=0.07$. T-tests explored the differences between groups for specific emotions, since both the interaction and group effect were not clearly non-significant. The Parkinson's group were worse at perceiving anger, $t(20) = -2.10$, $p<0.05$, and disgust, $t(20) = -2.35$, $p<0.05$. Fear and the other emotions were not significantly different between the two groups, $p>0.1$.

To compare the differences between the Ekman 50 and Ekman 60 scores in Phase 2, a mixed-design ANOVA was carried out, with group (Parkinson's or control) as the between-subjects factor, and task (Ekman 60 versus Ekman 50), along with emotion (anger, disgust, fear, happiness, sadness) as a within-subjects factor, with percentage correct in each task being compared.

This analysis revealed no main effect of task, $F_{(1,20)} = 0.04$, $p=0.839$. There was also no task by group interaction, $F_{(1,20)} = 0.00$, $p=0.994$. An effect of emotion, independent of task, was shown, $F_{(4,80)} = 23.31$, $p<0.001$, reflecting different accuracy rates for the emotions. There was a significant group effect, $F_{(1,20)} = 5.92$, $p<0.05$, with Parkinson's patients being worse than control participants. A borderline emotion by group interaction was revealed, $F_{(4,80)} = 2.58$, $p=0.056$. A task by emotion interaction was also significant, $F_{(2.11,\ 42.20)} = 8.10$, $p<0.005$. This reflects different performance by all participants on emotions depending on response alternatives. This will be explored. The task by emotion by group interaction was not significant, $F_{(2.11,\ 42.20)} = 0.63$, $p=0.544$. It is posited that this has occurred since the elimination of the surprise option elevated not just the Parkinson's patients' recognition rates for fear, but also those of the control group.

Paired-samples t-tests revealed a significantly higher recognition accuracy rate in the perception of fear in the Ekman 50 task than the Ekman 60 task, $t(21) = -2.98$, $p<0.01$. Thus, inclusion of surprise decreases accuracy in recognition of fear for both control participants and Parkinson's patients. There was also an increase in recognition accuracy rates for anger in the Ekman 60 task, $t(21) = 3.54$, $p<0.005$; this may reflect an influence of order, since the Ekman 60 task was presented after the Ekman 50 task. Recognition of anger seems to benefit from repetition of the task.

Although a group effect was revealed in this analysis, it is not focused on, since it is neutral to the hypothesis that task design alterations improve recognition of fear. The clinical sample is small (N=7). Separate analysis presented earlier, with larger samples[11] revealed group differences on the Ekman 60 but not the Ekman 50. Furthermore, between-subjects analysis with the whole population tested[12], revealed a task by emotion by group interaction [$F_{(3.04,\ 133.60)} = 2.52$, $p<0.05$]. This is more inkeeping with proposed hypotheses that Parkinson's disease is *not* associated with a general facial emotion recognition impairment. In addition, when sex of participant was included as a factor in the analysis of group performances on these tasks, the results resemble those reported when sex was not included as a factor. Please see Appendix 7 for more information.

9.7.8 Confusion analysis

Confusion analysis, as described in Section 9.4.1c, was applied to the data.

9.7.8a Faces tasks – Ekman 60 versus Ekman 50

Tables 9.3-9.6 summarise the responses of the participants from Phase 2, who completed *both* of these tasks. Misses, false positives, and accuracy rates are all included. All numbers are mean percentages.

[11] NB. Ekman 60 task: Parkinson's N=8; Ekman 50 task: Parkinson's N=12.

[12] NB. Ekman 60 task: Parkinson's N=8, Control N=16; Ekman 50 task: Parkinson's N=12, Control N=16.

Table 9.3: The pattern of responses to facial expressions of emotion, made by the Parkinson's group on the Ekman 60 task

		Depicted: Anger	Disgust	Fear	Happiness	Sadness	Surprise	Total label use	False positives
Perceived by the Parkinson's group	Anger	**78.6**	6.0	7.1	0.0	2.9	1.4	96.0	17.4
	Disgust	17.1	**87.1**	4.3	0.0	7.1	2.9	118.6	31.4
	Fear	1.4	1.4	**50.0**	0.0	2.9	4.3	60.0	10.0
	Happiness	0.0	0.0	1.4	**98.6**	0.0	2.9	102.9	4.3
	Sadness	0.0	1.4	1.4	1.4	**80.0**	1.4	85.7	5.7
	Surprise	2.9	4.0	35.7	0.0	7.1	**87.1**	136.9	49.7
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		21.4	12.9	50.0	1.4	20.0	12.9		

Table 9.4: The pattern of responses to facial expressions of emotion, made by the control group on the Ekman 60 task

		Depicted: Anger	Disgust	Fear	Happiness	Sadness	Surprise	Total label use	False positives
Perceived by the control group	Anger	**89.3**	6.0	2.7	0.0	1.3	0.0	99.3	10.0
	Disgust	2.7	**91.3**	2.0	0.0	6.0	0.7	102.7	11.3
	Fear	3.3	0.0	**71.3**	0.0	3.3	9.3	87.3	16.0
	Happiness	0.0	0.7	0.7	**99.3**	0.7	0.7	102.0	2.7
	Sadness	2.7	2.0	2.0	0.0	**86.7**	0.0	93.3	6.7
	Surprise	2.0	0.0	21.3	0.7	2.0	**89.3**	115.3	26.0
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		10.7	8.7	28.7	0.7	13.3	10.7		

Table 9.5: The pattern of responses to facial expressions of emotion, made by the Parkinson's group on the Ekman 50 task

		Depicted: Anger	Disgust	Fear	Happiness	Sadness	Total label use	False positives
Perceived by the Parkinson's group	Anger	**72.5**	11.7	8.3	0.0	1.5	95.0	22.5
	Disgust	13.3	**85.0**	10.8	0.0	8.5	118.3	33.3
	Fear	9.2	0.8	**76.7**	0.0	7.5	93.3	17.5
	Happiness	0.8	0.0	0.0	**100.0**	0.8	102.5	2.5
	Sadness	4.2	2.5	4.2	0.0	**81.7**	90.8	10.8
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		27.5	15.0	23.3	0.0	18.3		

Table 9.6: The pattern of responses to facial expressions of emotion, made by the control group on the Ekman 50 task

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Perceived by the control group	Anger	**78.7**	6.0	4.0	0.0	1.3	90.0	11.3
	Disgust	8.0	**92.0**	6.7	0.0	7.3	114.0	22.0
	Fear	10.7	0.0	**86.7**	0.0	8.7	106.0	19.3
	Happiness	0.7	1.3	1.3	**100.0**	0.7	104.0	4.0
	Sadness	2.0	0.7	1.3	0.0	**82.0**	86.0	4.0
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		21.3	8.0	13.3	0.0	18.0		

9.7.8a (i) Ekman 60

When comparing false positives, there was a significant effect of emotion, $F_{(5,100)} = 15.14$, $p<0.001$. There was a significant effect of group, $F_{(1,20)} = 5.75$, $p<0.05$. This was qualified by a significant interaction between group and emotion, $F_{(5,100)} = 3.40$, $p<0.01$. Post-hoc tests revealed that the Parkinson's group were more likely to use the label 'disgust' incorrectly for faces in the Ekman 60, $t(20) = 2.88$, $p<0.01$, and they were also more likely to use the label 'surprise' incorrectly, $t(20) = 2.37$, $p<0.05$. The groups did not differ in their use of other emotional labels, $p>0.25$.

When angry faces were shown, an interaction between the incorrect labels (misses) and group was revealed, $F_{(2.52,\ 50.34)} = 10.15$, $p<0.001$. No effect of group was shown, $F_{(1,20)} = 3.27$, $p=0.086$. There was a significant effect of emotion, $F_{(2.52,\ 50.34)} = 8.37$, $p<0.001$. Post-hoc analysis revealed that the Parkinson's group were more likely than control participants to label angry faces as 'disgusted', $t(7.64) = 3.23$, $p<0.05$. There were no other significant differences between groups in their misses, $p>0.1$

When fear faces were shown, there was a significant effect of emotion, $F_{(1.82,\ 36.41)} = 54.16$, $p<0.001$. There was also a borderline group effect, $F_{(1,20)} = 4.19$, $p=0.054$, and a significant interaction between emotion and group, $F_{(1.82,\ 36.41)} = 3.55$, $p<0.05$. Post-hoc tests revealed that 'surprise' was more often used by the Parkinson's group to label fearful faces, $t(20) = 2.18$, $p<0.05$. No other labels were used more by one group than another, $p>0.098$.

No other differences or interactions between groups and emotion were revealed in the misses on this task, $p>0.18$.

9.7.8a (ii) Ekman 50

The Parkinson's group and the control group did not differ significantly in their label use (misses or false positives) for any emotion in the Ekman 50: $p>0.13$ for all main effects and interactions.

9.7.8a (iii) Comparison of confusions across face tasks and groups

False positives were compared across the two Ekman face tasks and groups, with a 2x2x5 mixed-design ANOVA, with task (Ekman 60, Ekman 50) and group (Parkinson's, control) as independent variables, and the numbers of times each emotional label (emotion – anger, disgust, fear, happiness, sadness) is used incorrectly in each task as the dependent variable. This revealed a borderline effect of task, $F_{(1,20)} = 4.22$, $p=0.053$, no interaction of task and group, $F_{(1,20)} = 0.87$, $p=0.363$, and effect of emotion, $F_{(2.64, 56.79)} = 15.91$, $p<0.001$. An emotion by group interaction was revealed, $F_{(2.64, 56.79)} = 5.56$, $p<0.005$. The task by emotion interaction was not significant, $F_{(4,80)} = 1.64$, $p=0.184$, nor was the task by emotion by group interaction, $F_{(4,80)} = 0.61$, $p=0.631$. This non-significance may be because the exclusion of surprise in the Ekman 50 elevated not just the accuracy rate for fear of the Parkinson's group, but also of the control group. There was a main effect of group, $F_{(1,20)} = 8.58$, $p<0.01$.

Paired-samples t-tests revealed that the Parkinson's group used the label 'sadness' more often in the Ekman 50 task than in the Ekman 60 task, $t(6) = -2.83$, $p<0.05$. The controls, by contrast, tended to use the label 'disgust' more in the Ekman 50 task than the Ekman 60 task, $t(14) = -2.05$, $p=0.06$.

The mistaken responses when each emotion was represented were compared across tasks and groups. See Chapter 10 for further comparisons of control group results. The Parkinson's group mistook disgust for 'anger' more in the Ekman 50 than in the Ekman 60 task, $t(6) = -2.49$, $p<0.05$. No other differences between the groups exist in their confusions, $p>0.15$ for all interactions and between-subjects effects. Since erroneous responses to fear between the two tasks for either group do not differ, this suggests that the low accuracy rates for fear perception are largely explained by surprise.

9.7.8b Voices task

Tables 9.7 and 9.8 show the pattern of response by the Parkinson's group and control group from both Phase 1 and Phase 2 combined. All numbers are mean percentages.

Table 9.7: The pattern of responses to vocal expressions of emotion, made by the Parkinson's group on the verbal prosody task

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Perceived by the Parkinson's group	Anger	**69.4**	13.9	4.4	7.8	1.1	96.7	27.2
	Disgust	18.9	**43.3**	5.0	9.4	13.3	90.0	46.7
	Fear	6.1	16.7	**63.3**	13.9	6.1	106.1	42.8
	Happiness	2.8	10.0	6.7	**61.1**	2.2	82.8	21.7
	Sadness	2.8	16.1	20.6	7.8	**77.2**	124.4	47.2
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		30.6	56.7	36.7	38.9	22.8		

Table 9.8: The pattern of responses to vocal expressions of emotion, made by the control group on the verbal prosody task

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Perceived by the control group	Anger	**79.1**	16.9	0.6	4.1	0.3	100.9	21.9
	Disgust	13.1	**60.9**	3.4	5.9	10.3	93.8	32.8
	Fear	1.3	6.9	**75.6**	10.0	5.3	99.1	23.4
	Happiness	5.3	8.8	8.4	**72.5**	1.9	96.9	24.4
	Sadness	1.3	6.6	11.9	7.5	**82.2**	109.4	27.2
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		20.9	39.1	24.4	27.5	17.8		

The use of false positives was explored for the vocal task. The Parkinson's and the control group differed significantly in their false positive use, $F_{(1,48)} = 8.65$, $p<0.01$.

There was a significant effect of emotion, $F_{(4,192)} = 6.30$, $p<0.001$. There was also a significant emotion by group interaction, $F_{(4,192)} = 2.59$, $p<0.05$. Post-hoc t-tests revealed that the Parkinson's group were more likely to use the labels 'sadness', $t(48) = 2.74$, $p< 0.01$, and 'fear', $t(48) = 3.90$, $p<0.001$, in the vocal task. The two groups do not differ in their use of other emotions, $p>0.089$.

The label use for each emotion was examined. No effect of emotion was displayed when disgusted voices were heard, $F_{(3,144)} = 2.13$, $p=0.099$, but was there an emotion by group interaction, $F_{(3,144)} = 3.40$, $p<0.05$. There was a significant effect of group, $F_{(1,48)} = 8.99$, $p<0.005$. Post-hoc tests showed that Parkinson's group were more likely than the control group to perceive the disgusted voices as sounding 'fearful', $t(48) = 3.17$, $p<0.005$, and 'sad', $t(23.10) = 2.80$, $p<0.05$, but not other emotions, $p>0.47$.

There was a significant effect of emotion displayed when fearful voices were presented, $F_{(2.38,\ 114.17)} = 22.46$, $p<0.001$. There was also a significant effect of group, $F_{(1,48)} = 5.16$, $p<0.05$. This was qualified by a significant interaction, $F_{(2.38,\ 114.17)} = 2.91$, $p<0.05$. The Parkinson's group described fearful voices as sounding like 'sadness', $t(48) = 2.44$, $p<0.05$, and to a lesser extent 'angry', $t(18.60) = 1.85$, $p=0.08$, but not any other emotion, $p>0.46$.

There were no significant group differences in the label use for happy, angry, or sad voices, $p>0.08$, or significant emotion by group interactions, $p>0.17$.

9.7.8c Gesture task

Analysis of false positives and misses on each task revealed no significant differences between the Parkinson's group and the control group, $p>0.12$.

9.7.9 Response time analysis for the voices task

Since the Parkinson's patients struggled with the vocal emotion recognition task in comparison to the control group, it was postulated that perhaps differences in sensitivity to stimuli might be reflected in reaction times.

As mentioned earlier, in Phase 2, experiments were designed in order to measure response times for participants. Reaction times were analysed using a 2x5 mixed-design ANOVA. The between-subjects factor was group (Parkinson's or control) and the within-subjects factor was mean reaction time for each emotional stimulus. There was an effect of emotion, $F_{(4,88)} = 7.79, p<0.001$. There were no differences between groups, $F_{(4,88)} = 0.83, p=0.511$, or interaction between reaction times to each emotion and group, $F_{(1,22)} = 0.17, p=0.682$.

Correct responses only were examined in the second analysis. Again, reaction times for each emotion was submitted to a 2x5 mixed-design ANOVA. A significant effect of emotion was observed, $F_{(1.59,\ 33.36)} = 6.83, p<0.01$. The two groups did not differ, $F_{(1,21)} = 0.27, p=0.609$, nor was there a significant interaction between response times for each emotion and group, $F_{(1.59,\ 33.36)} = 0.13, p=0.833$.

9.8 Summary

The second phase of this study replicates difficulties in perceiving vocal emotion in the Parkinson's population found in Phase 1. Again, the Parkinson's patients achieved similar recognition accuracy scores as the control participants for the gestural emotion task. As with the previous phase, the Ekman 60 task, which included the emotion of surprise, the Parkinson's group had problems recognising fear, consistently confusing this with surprise. By contrast, in the Ekman 50 test, which did not include surprise as a response option or as a stimulus category, the Parkinson's participants had no difficulties in perceiving fear when compared with the control group. Indeed, in the alternative face task (which also excluded surprise), again, the Parkinson's patients were not impaired in their perception of fear. The contrast between tasks is particularly profound, especially given that in the within-subjects condition all participants received the Ekman 60 task after the Ekman 50 task, so any order effects would be expected to lead to an improvement in certain categories, but this was not the case.

9.9 General discussion

9.9.1 Difficulties in recognising vocal emotion

Much research has explored language-processing deficits in Parkinson's disease. Such deficits, which include problems in understanding complex sentences when read or heard, are widespread (Angwin et al., 2004; Grossman et al., 2003) and may result from damage to basal ganglia circuits between Broca's area and prefrontal cortex (Lieberman et al., 1992). Often these problems are related to either a reduction in working memory resources, reduced information processing speed, or to deficits in selective attention. The results on the current vocal task might reflect these variables. Parkinson's patients were not slower to respond to the stimuli than control participants, so response times cannot account for the difficulties in vocal emotion perception. Perhaps there is a problem with interpreting prosody – emotional and non-emotional – in Parkinson's disease. This argument conflicts with Kan and colleagues' (2002) findings in which Parkinson's patients had intact prosody perception and understanding from written descriptions, however.

The Parkinson's group tended to use the labels 'fear' and 'sadness' for vocal stimuli more often than the control group. These labels were commonly used to label disgust.

IQ differed between groups in Phase 2 but not Phase 1, yet deficits were found in both test phases in the vocal task, therefore, it is unlikely that the higher IQ scores of the control participants in Phase 2 could account for the lower accuracy scores by Parkinson's patients on the vocal emotion task.

9.9.2 Gestural emotion recognition preserved

If poor motor imagery is related to poor motor representations in the brain, then gestural interpretation should be difficult for Parkinson's patients. Yet, the present study has revealed that the Parkinson's participants had no problems in interpreting gestural emotions. One can ask why gestural representation is spared: Parkinson's disease is chiefly characterised by degeneration in the substantia nigra but not cortex[13]. Presently, there is no evidence for mirror neurons in subcortical regions; motor mirror system circuits involve cortical routes, via STS, parietal, premotor cortices etc., but not the substantia nigra, so this could explain the maintenance of gestural perception by the Parkinson's patients.

The Parkinson's population examined in the current study were all diagnosed within the past five years, and averaged stage 2 on the Hoehn and Yahr scale (1967). Since the disease is at an early stage in all participants, they may not yet experience problems with motor imagery. Alternatively, perhaps motor imagery and representations of movement are not as related as has been proposed.

Gallagher and Frith (2004) found that perception of expressive hand gestures (representing internal states) but not instrumental hand gestures (commands like 'come here') activated regions around the STS, the amygdala, temporal pole, and anterior paracingulate cortex. Thus, perhaps the gestures in the present study were not processed in the same way that natural gestures are processed because of their symbolic nature.

[13] Some cortical pathology does occur in Parkinson's but this is relatively uncommon and does not appear to be a consequence of the illness, since similar changes occur in age-matched controls (Jellinger, 1990).

It is not clear whether a mirror system is compromised in the Parkinson's population studied, but it can be concluded that Parkinson's patients do not seem to have problems in the interpreting dynamic gestural representations of emotion in early stages of the illness.

9.9.3 Facial emotion recognition

9.9.3a A theoretical caveat

The present research demonstrates that the use of different facial tasks within the same population produces contrasting results. In the first phase of this study, a deficit for interpreting fear from faces was observed, and this emotion seemed to be consistently perceived as surprise by *all* participants. This confusion was exacerbated in the Parkinson's group. Consequently, the task was adapted to exclude surprise as a stimulus and response alternative. An alternative face task was also created using different actors; this did not include surprise. In the second phase of this study, the Parkinson's patients had no significant difficulty in labelling fearful faces as fear in these two face tasks. All participants had difficulties perceiving fear in the Ekman 60 task, and the Parkinson's group were significantly worse than the control group, in both Phase 1 and Phase 2. A learning effect could explain why the group difference for fear perception in the Ekman 60 task in Phase 2 was not as distinct as in Phase 1 (group difference for fear recognition in Phase 2, p=0.05): in Phase 2, the Ekman 60 was always given at the end of the experimental session and the Ekman 50 at the beginning. Since an impairment in fear perception was shown in the Ekman 60 task, this is particularly salient, as order effects generally lead to an improvement in emotion perception. Given that fear is recognised accurately in the two alternative face tasks, and in other modalities, it is therefore unlikely that the Parkinson's patients examined have severe problems in the perception of fear.

As fear recognition deficits are commonly reported in neuropsychological research of people with amygdala damage, Parkinson's disease, and Huntington's disease (Adolphs et al., 1994; Adolphs et al., 1995; Adolphs et al., 1999; Calder, Young, Rowland et al., 1996; Kan et al., 2002; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 2003; Sprengelmeyer et al., 1999; Sprengelmeyer, Young, Sprengelmeyer et al., 1997; Wang et al., 2002; Yip et al., 2003), it is suggested that before accepting that the interpretation of fear is compromised in these populations, more tests that exclude the surprise option should be implemented. The deficits observed in these studies may be a consequence of the inclusion of surprise in the recognition task.

9.9.3b A problem with surprise

Parkinson's patients seem to have elevated sensitivity or response bias for surprise. When this option is available to them, they are significantly more likely than control participants to use it to describe other emotional stimuli. This is not the first study to highlight a potential surprise processing dysfunction. Dujardin and colleagues (2004) reported that Parkinson's patients perceived more surprise in emotional facial expressions than control participants. In Dujardin and colleagues' study, fear was actually excluded as a stimulus and response scale, because the authors claimed that fear expressions are displayed in social situations less often than the other emotions of anger, disgust, and sadness. The authors speculated that perhaps Parkinson's patients are more likely to encounter surprise in social interactions, as a consequence of the symptoms of their disease.

In the present study, in the Ekman 50 task, when fear faces were shown, all bar two participants (across both control and Parkinson's) commented that a surprise label would be more apt than the five that were offered.

9.9.4 Neural explanations

A dissociation between emotion perception from visual cues and auditory cues has been demonstrated in the current research. The Parkinson's group had difficulty in perceiving vocal emotion in contrast to control participants, and this did not extend to gestural cues. The neuropsychological theory of unified emotion mechanisms would suggest that any deficits observed in one task should extend to others, on account of independent neural substrates for the processing of specific emotions. This does not seem to be the case for the particular patient group studied here. The dissociation between the auditory and visual channels could indicate that perhaps separable neural pathways process emotions presented in separate modalities, and Parkinson's disease affects the pathway involved in perception of vocal emotion more than pathways that subserve visual perception of emotion. This speculation, however, is questionable, since facial and gestural emotion perception abilities (which are both determined from visual tasks) are dissociable in the study of age (Chapter 8). Combined, these two studies suggest that emotions portrayed in different channels of communication (even within the same modality) might be processed by partially independent pathways.

9.9.5 Background tasks

The current study has demonstrated that Parkinson's sufferers self-report more experiences of fear and discomfort. Variations in experience are not related to some dysfunction in fear processing. Generally, Parkinson's patients are reported as becoming more irritable as the disease progresses. In the present study, scores reflecting high levels of discomfort and fear are correlated with elevated experience of depression. Thus, it is possible that this irritability has been tapped by the Wolpe and Lang (1964) scale.

The Parkinson's patients studied here were also more depressed than control participants. This is not surprising, given the literature regarding the prevalence of depression in this population (McDonald et al., 2003; Pearce, 1995; Rojo et al., 2003). The patients in Phase 1 experienced higher levels of depression than those in Phase 2. Chapters 3, 4, and 5 report a relationship between depressed mood and impairments in recognising disgust represented by the voice and by body movements. The current research demonstrated a relationship between high depression scores and difficulties in perceiving disgust from faces in the Ekman 60. No correlation between depression scores and recognition accuracy of disgust from vocal or gestural cues were observed, so perhaps facial tasks are more sensitive to the impact of depression on disgust emotion perception. It would be of interest to investigate this idea further.

It is important to note that there was no main effect of sex in any of the analyses (please see Appendix 7).

9.9.6 Conclusions

The present study has revealed an impairment in perceiving vocal emotion in Parkinson's disease. An issue arises regarding whether difficulties in complex sentence and language processing often observed in Parkinson's disease could explain these results, or whether there is an impairment specific to vocal emotion perception. Further research exploring the recognition of nonverbal vocal emotion (see Scott et al, 1997), such as screaming, crying, laughing, retching, and roaring would address such a question.

Parkinson's patients are comparable to control participants in their recognition accuracy for gestural and perhaps for facial emotion as well. This indicates that the neural regions affected by Parkinson's disease might not be involved in the processing of visually portrayed emotion.

Finally, central to this research is the finding that deficits in facial fear perception may be falsely established from forced-choice face tasks as a consequence of the inclusion of surprise. The present study has confirmed that a fear deficit may be eliminated if the task is adapted slightly. This acts as a caution for neuropsychological investigations to consider the design of the tasks employed before concluding that deficits in facial emotion perception exist.

10 THE RELATIONSHIPS BETWEEN CHANNELS OF EMOTIONAL COMMUNICATION

This thesis has been concerned with the perception of emotion from a number of communication channels. Consequently, the aim of this chapter is to explore the differences in relationships between emotions expressed in each of the communication channels.

10.1 Introduction

Neuropsychological studies investigating the recognition of emotions have typically focused on a single parameter of emotion processing, such as facial emotion perception. This thesis has highlighted that by restricting research to the exploration of just one communication channel, studies are limiting the extent to which conclusions can be generalised. A myriad of cues, as well as facial expressions, enable inferences to be drawn about another's emotional state. In everyday situations, people unwittingly express emotions in a variety of ways, nonverbally and verbally. Particular emotions may be more readily expressed in certain communication channels. To understand the relative contribution of different communication channels to our interpretation of each emotion, their ease of recognition and their confusability can be compared and contrasted.

10.2 Six versus five emotions – exploration of the Ekman faces task

Chapter 9 proposes that the inclusion of surprise in the facial emotion task may disrupt or interfere with the distinction of fear, and that this might be exacerbated in clinical participants. As a consequence, it was suggested that researchers exercise caution when interpreting results of such facial emotion tasks. The present chapter seeks to explore differences in a normal population in their recognition accuracy for fear when surprise is included or excluded in a face task. Displayed fear is consistently confused with surprise, yet the reverse confusion (surprise labelled as fear) is less common (Calder et al., 2003; Rapcsak et al., 2000). Surprise is short-lived and lacks valence, which many researchers argue is evidence for it being a transient state that precedes other emotions (Ortony & Turner, 1990), namely fear or happiness – the two emotions with which surprise is most often confused. For instance, if someone jumps out from the shadows late at night, initially, surprise will be experienced, but this will quickly be followed by fear. Alternatively, if a long-lost friend arrives unexpectedly, surprise will be felt, but this will soon be followed by happiness. The consistent confusion with fear may result from surprise being viewed more often in social interactions than fear. Surprise does not, however, have a specific vocal profile (Banse & Scherer, 1996; Van Bezooijen et al., 1983), or distinct galvanic reflex (Patterson, 1930), or distinct physiological profile, unlike fear and the other basic emotions. Furthermore, fear is regarded as the most difficult emotion to perceive from the face. A considerable number of clinical studies have reported a deficit in fear processing from facial expressions. Thus, it is important to understand whether emotion perception difficulties seen in populations are genuine and not a consequence of a particular method of testing.

The first study of this chapter sought to compare and contrast recognition accuracy and confusion between emotions on the faces task with six or with five emotions. A between-subjects comparison is presented first, followed by a within-subjects comparison.

10.2.1 Method 1 between-subjects

10.2.1a Participants

There were two groups of participants. The first group completed the faces task, which included surprise (Ekman 60). These participants were 20 volunteers from the St Andrews community. Their mean age was 42.25 years (s.d. = 3.14). Nine were male and 11 were female.

The second group completed the faces task, which excluded surprise (Ekman 50). They were matched with the former group in terms of age and sex. These participants were 20 volunteers, attending the University of St Andrews part-time degree programme. Their mean age was 41.29 years (s.d. = 2.92). Nine were male and 11 were female.

10.2.1b Stimuli and procedure

The stimuli and procedure for Ekman 60 and Ekman 50 are described in Chapter 2.

10.2.2 Results 1 between-subjects

10.2.2a Difficulty levels

The recognition accuracy for specific emotions in both of these tasks is summarised in Figure 10.1. This can be interpreted as a measure of difficulty.

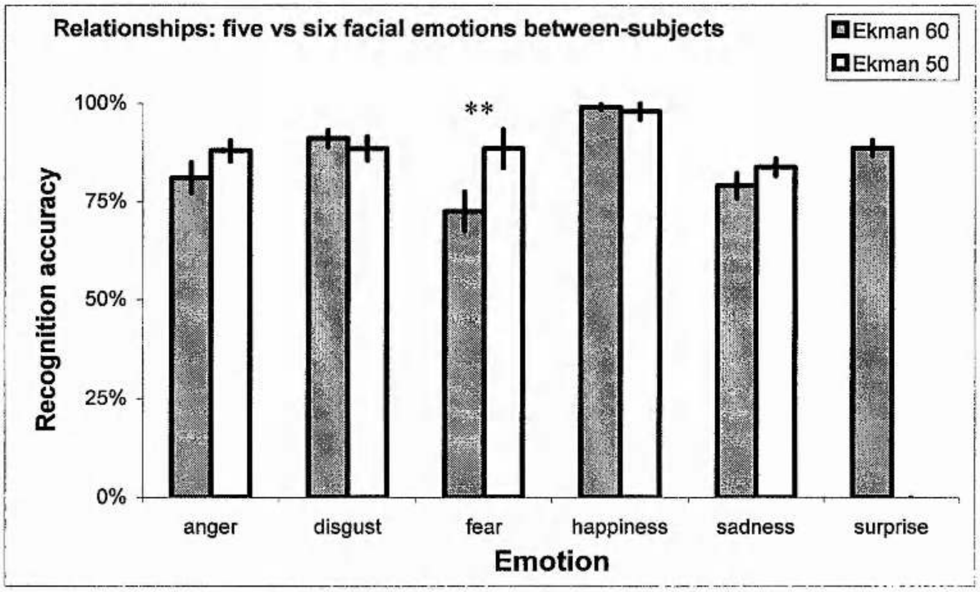


Figure 10.1: Recognition accuracy rates for facial expressions with five or six alternative emotions – between-subjects comparison.

** $p<0.05$

A 2x5 mixed-design ANOVA explored the results. The between-subjects factor was task (Ekman 50 and Ekman 60) and the within-subjects factor was emotion (recognition accuracy rate for anger, disgust, fear, happiness, sadness). There was a main effect of emotion, $F_{(2.82,107.12)} = 17.33$, $p<0.001$. Particular emotions were recognised with greater ease than others. The effect of task was not significant, $F_{(1,38)} = 2.78$, $p=0.104$. This means that no task was easier than the other. There was a significant task by emotion interaction, however, $F_{(2.82,107.12)} = 4.15$, $p<0.005$. Independent t-tests revealed higher levels of recognition accuracy for fear in the Ekman 50 task, $t(25.83) = -3.38$ $p<0.005$. No other emotions differed between tasks, $p\geq0.1$.

10.2.2b Confusion analysis

The responses for all of the stimuli for the two groups were placed into confusion matrices (Tables 10.1 and 10.2). These tables enable us to see whether the same emotions are confused when surprise is included in the task, or whether the pattern of errors changes. All numbers in the tables represent mean percentages.

Table 10.1: Confusion matrix showing patterns of responses in the Ekman 60 task.

		Depicted							
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Surprise**	**Total label use**	**False positives**
Perceived on the Ekman 60 task	**Anger**	**81.0**	7.5	1.0	0.0	0.5	0.0	90.0	9.0
	Disgust	9.5	**91.0**	4.0	0.0	10.0	0.0	114.5	23.5
	Fear	3.0	1.5	**72.5**	0.0	9.0	10.0	96.0	23.5
	Happiness	0.0	0.0	0.0	**99.0**	0.0	1.5	100.5	1.5
	Sadness	1.5	0.0	2.0	0.0	**79.0**	0.0	82.5	3.5
	Surprise	5.0	0.0	20.5	1.0	1.5	**88.5**	116.5	28.0
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		19.0	9.0	27.5	1.0	21.0	11.5		

Table 10.2: Confusion matrix showing patterns of responses in the Ekman 50 task.

		Depicted						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived on the Ekman 50 task	**Anger**	**87.9**	11.1	5.3	2.1	1.1	107.4	19.5
	Disgust	4.7	**88.4**	4.7	0.0	7.9	105.8	17.4
	Fear	5.3	0.5	**88.4**	0.0	6.8	101.1	12.6
	Happiness	0.5	0.0	1.6	**97.9**	0.5	100.5	2.6
	Sadness	1.6	0.0	0.0	0.0	**83.7**	85.3	1.6
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		12.1	11.6	11.6	2.1	16.3		

Statistical analysis of the pattern of responses excluded surprise, since this was only included in one task. Differences in the total number of incorrect responses (false positives) made with each emotional label in the two tasks were explored using a 2x5 mixed-design ANOVA. The between-subjects factor was task (Ekman 50 and Ekman 60) and the within-subjects factor was emotion (the number of times anger, disgust, fear, happiness, sadness labels were used incorrectly). There was a main effect of emotion, $F_{(2.43, 92.21)} = 13.13, p<0.001$. No effect of task can be reported, $F_{(1,38)} = 0.40$, $p=0.530$. A task by emotion interaction bordered significance, $F_{(2.43, 92.21)} = 2.71$, $p=0.061$. As a consequence of this trend for significance, t-tests explored whether there were specific emotional labels that were used more or less in one task than the other. These revealed that fear (as a label) was used incorrectly more often in the Ekman 60 task, $t(38) = -2.25, p<0.05$. This is of interest, as it suggests that lower accuracy for fear in this task is not due to a tendency to under-use the label of fear. No other false positive rates differed between the two groups, $p>0.077$.

The incorrect responses for particular depicted emotions were explored in more detail. If the inclusion of surprise does not confound distinctions for other emotions, no differences in labelling between the two tasks should be revealed by the subsequent analyses. 2x4 mixed-design ANOVAs were carried out, with task (Ekman 50 and Ekman 60) as the between-subjects variable, and emotion (all but the target emotion) as the within-subjects variable. For instance, in order to explore whether the two groups differ in their perception of fear depictions, the number of times participants in each group respond with the labels anger, disgust, happiness, and sadness when fearful faces are presented will be entered into the ANOVA. For all emotions, there were no significant group differences (p>0.32), and no significant group by emotion interactions (p>0.21).

This means that responses to the Ekman 50 and Ekman 60 task do not differ, except for the number of times fear is accurately recognised, and the number of times the label of fear is applied to other expression stimuli. This is important to note, as it suggests that the problems in fear recognition observed in the Ekman 60 task cannot be explained by confusions with any other emotion bar surprise, and this problem cannot be related to a failure to use the fear label. Fear is mislabelled as surprise when surprise is a legal response option.

10.2.3 Method 2 within-subjects

In order to explore Ekman 60 versus Ekman 50 thoroughly, a within-subjects design was employed as well.

10.2.3a Participants

Six women and nine men volunteered to take part in the present study. They had a mean age of 62.0 years (s.d. 5.89). While the data from these participants have been presented in Chapter 9, that chapter focused on group differences, whereas this one focuses on a comparison between performances on tasks.

10.2.3b Stimuli and procedure

The stimuli and procedure are the same as in Section 10.2.1b, except all participants completed the Ekman 50 first. Then, an hour later they were given the Ekman 60. This sequence was chosen with the intention of preventing order effects falsely elevating difficulties in recognising fear in the Ekman 50 task.

10.2.4a Difficulty levels

The recognition accuracy for emotions in both of these tasks is summarised in Figure 10.2.

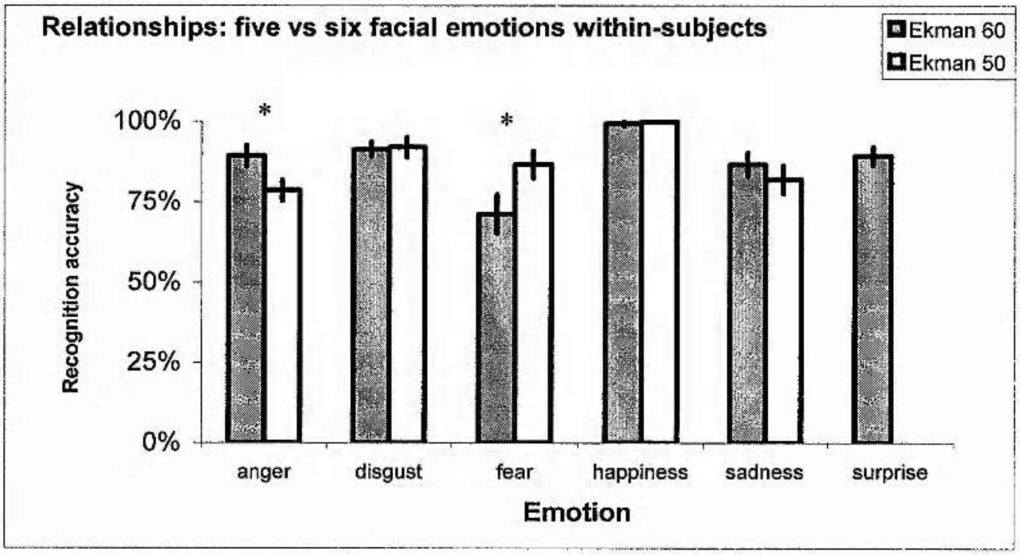


Figure 10.2: Recognition accuracy rates for facial expressions with five or six alternative emotions - within-subjects comparison.
* $p<0.05$

A 2x5 mixed-design ANOVA explored the results. This revealed a main effect of emotion, $F_{(4,56)} = 10.05, p<0.001$. There was no effect of task, $F_{(1,14)} = 0.04, p=0.848$. This means that neither the Ekman 50 nor the Ekman 60 was easier. The emotion by task interaction was significant, $F_{(4,56)} = 5.96, p<0.05$. Paired-samples t-tests revealed that fear was interpreted more readily in the Ekman 50 task, $t(14) = -2.43, p<0.05$. Anger attained higher accuracy rates in the Ekman 60, $t(14) = 2.42, p<0.05$. This might reflect an effect of order, since the Ekman 60 was presented after the Ekman 50 and the same faces were presented in both. Recognition accuracy rates for all other emotions did not differ, $p>0.13$.

10.2.4b Confusion analysis

The pattern of responses for these tasks is presented in Tables 9.4 and 9.6 in the previous chapter.

Confusion analysis was performed on these results. Surprise was excluded, as no comparison between the two tasks for this variable can be made. As before, 2x5 mixed-design ANOVA was used to explore differences in false positive rate. The between-subjects factor is task (Ekman 50 and Ekman 60) and the within-subjects factor is emotion – the number of times each emotional label is used incorrectly (for anger, disgust, fear, happiness, sadness). This revealed no differences between the two tasks in false positive rate, $F_{(1,28)} = 1.45$, p=0.239. There was an effect of emotion, $F_{(3.22,\ 90.39)} = 8.94$, p<0.001, but no significant emotion by task interaction, $F_{(3.22,\ 90.39)} = 1.25$, p=0.296.

Misses were explored when each emotion was represented, using a 2x4 mixed-design ANOVA, as before, with task as the between-subjects factor (Ekman 50 and Ekman 60), and emotion as the within-subjects factor (all emotions except the target). Responses to anger were bordering significance: emotion, $F_{(2.24,\ 62.70)} = 6.81$, p<0.005; emotion by task, $F_{(2.24,\ 62.70)} = 2.74$, p=0.067; task, $F_{(1,.28)} = 9.50$, p<0.005. Paired-samples t-tests explored this further, since the interaction was marginally significant. These revealed that during the Ekman 50 task, participants confused anger with fear more than in the Ekman 60 task: $t(28) = 2.49$, p<0.05. There was a trend for participants to confuse anger with disgust in the Ekman 50 task as well, $t(28) = 1.97$, p=0.058. This could reflect the higher accuracy rates for anger in the Ekman 60 task, which, as posited earlier, might be a consequence of the influence of order. No other mistaken responses differed between tasks, p>0.13.

10.2.5 Discussion

There are several states that are not considered emotions in themselves, yet involve prototypical facial expressions. For instance, Carroll and Russell (1996) found that providing a specific context or manipulating the choice of response alternatives led to facial expressions of anger[14] being labelled as determination. The facial action coding units of anger and determination may have some overlap (Ekman & Friesen, 1978). Thus, contextual cues are important when making distinctions between state and emotional facial expressions in a forced-choice task. The confusion between determination and anger resembles that between fear and surprise. It is often contended that surprise is more of a transitory state, preceding other emotions, as mentioned earlier. Perhaps states are less difficult to classify as a facial configuration rather than a specific emotion. This could explain the mislabelling of fear as surprise in the present study within the facial task. This provides an indication that inclusion of different response alternatives in such a task can substantially confound the results.

Healthy individuals have difficulties perceiving fear in the Ekman 60 task, and these are reduced when that task is altered by excluding surprise as a response alternative and stimulus category. Clinical participants exhibit impairments for fear in the task that includes surprise in comparison to a control group, but not when surprise is excluded (see Chapter 9). Therefore, it is possible that clinical participants who are only tested using the task that includes surprise will demonstrate impairments in perceiving facial fear that do not actually reflect problems in fear perception, but rather the task design or surprise perception. Forced-choice tasks have their disadvantages and the present study has highlighted one of these. Populations in which a facial fear recognition deficit is found should perhaps be re-examined using a facial task that excludes surprise as a choice of label. It is possible that difficulties in perceiving fear are just aggravated by the inclusion of this label.

10.3 A comparison of face, voice, and gesture perception

Much attention in emotion research has been drawn to the way in which emotions relate. Theories and models pioneered by Woodworth and Schlosberg (1954), and developed further by Russell (1980), support the concept that emotions can be

[14] Depicted in pictures from Ekman and Friesen (1976) and Matsumoto and Ekman (1988)

arranged in a space, defined by specific dimensions. The differences between each emotion are determined by the emotions' positions in relation to these dimensions. Since emotions seem to have fundamentally distinct expressive, physiological, and experiential components, however, another school of thought proposes that emotion perception is categorical: that there are distinct perceptual shifts in recognising each emotion displayed by others. The demonstration that emotions may be selectively impaired (Adolphs et al., 1995; Calder, Young, Rowland et al., 1996; Lawrence et al., 2002; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 1999) has bolstered this view that emotions are structured categorically and thus, each emotion has an independent neural substrate.

In order to understand the relationships between emotions, using more than one communication channel could be useful. For example, should emotions and their relationships to each other be defined by their position within emotional space, it would be predicted that regardless of the mode of presentation, particular emotions would be more readily confused with one another. It has already been demonstrated in Chapters 8 and 9 that recognition of particular channels of emotion are affected at different rates by certain circumstances (ageing and Parkinson's disease); thus, it is predicted that relationships between emotions represented by different communication channels will differ in the normal population.

The second part of this chapter focuses on a within-subjects comparison of recognition accuracy rates for each emotion across three communication channels. Patterns of responses between each channel will also be explored.

10.3.1 Method

10.3.1a Participants

The same participants described in Section 9.6.1b took part in this study. Their details are summarised in Table 10.3.

Table 10.3: Participant summary

Sex	6 females, 10 males
Mean age (years)	62.19 (s.d. 6.15)
Mean IQ	119.9 (s.d. 3.30)
Education (years)	15.88 (s.d. 3.83)
Beck Depression Scores	range 0-14 (out of 63)

10.3.1b Stimuli and procedure

The Ekman 50 face task, the full-light movies, and the verbal vocal task outlined in Chapter 2 were used in this investigation. The participants completed the tasks in the above order.

10.3.1c Analysis

10.3.1c (i) Recognition accuracy scores and false positives

All data will be submitted to 3x5 mixed-design ANOVAs, with task (facial, vocal, gestural) as the independent variable, and recognition rate, or false positive rate for each emotion (anger, disgust, fear, happiness, sadness) as the dependent variable. False positive rate refers to the number of times each emotional label is used incorrectly.

10.3.1c (ii) Misses

An ANOVA will be carried out for each emotion, in order to compare the misses between tasks, with task (facial, vocal, gestural) and the number of times each emotion is mistaken for the target emotion (four from anger, disgust, fear, happiness, sadness) as the within-subjects factors. For instance, when disgust is represented, the within-subjects factors will be task (facial, vocal, gestural) and emotion (anger, fear, happiness, sadness) – that is, the number of times that emotion is labelled instead of disgust when disgust is represented.

10.3.2a Recognition accuracy rates

The participants' recognition accuracy scores on each of the tasks are shown in Figure 10.3.

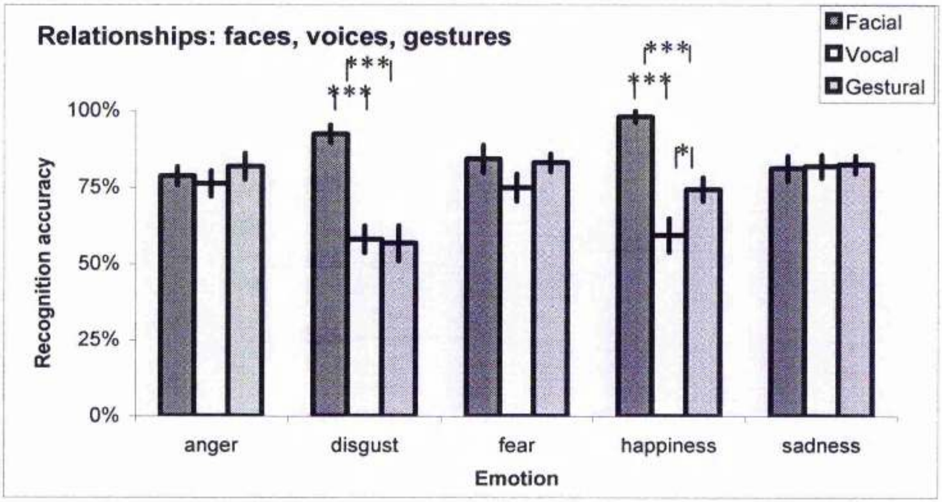


Figure 10.3: Recognition accuracy rates for the facial, vocal, and gestural tasks.
* $p<0.05$ *** $p<0.001$

The recognition accuracy per emotion was compared across tasks. A main effect of emotion was revealed, $F_{(4,180)} = 5.90$, $p<0.01$. There was a significant effect of task, $F_{(2,45)} = 12.30$, $p<0.001$. This was qualified by a significant emotion by task interaction, $F_{(4,180)} = 8.81$, $p<0.001$.

The vocal and gestural representations of disgust achieved lower accuracy rates than the facial representations of disgust: vocal, $t(30) = -6.49$, $p<0.001$; gestural, $t(22.41) = 5.51$, $p<0.001$. Happiness vocalisations were less readily interpreted than facial happiness portrayals, $t(18.43) = -6.66$, $p<0.001$. Facial happiness also attained higher accuracy rates than gestural happiness, $t(21.68) = 5.52$, $p<0.001$. Moreover, gestural displays of happiness were more accurately recognised than vocal representations, $t(30) = -2.23$, $p<0.05$. All other comparisons were not significant, $p>0.14$.

In summary, faces best communicate disgust. Happiness is also easily interpreted from facial cues. The voice is not a good conveyor of happiness. Other emotions do not differ between communication channels in the present study.

10.3.2b Confusion analysis

In order to understand the relationships between emotions and modalities, the incorrect responses were compared across tasks. Tables 10.4-10.6 show the confusion for these tasks. Analysis was performed on the false positives and the misses when each emotion was represented. Overall misses were not examined, as these would reflect the differences in recognition accuracy rates.

Tables 10.4-10.6: Pattern of responses on the (10.4) vocal task, (10.5) facial task, and (10.6) gestural task.

10.4 Voices		**Depicted**						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived on the vocal task	**Anger**	**76.3**	19.4	1.3	6.9	0.0	103.9	27.6
	Disgust	14.5	**58.1**	4.6	7.6	11.1	95.8	37.8
	Fear	1.5	10.6	**76.0**	14.8	6.0	108.9	32.9
	Happiness	5.7	6.9	5.0	**59.4**	1.0	78.0	18.6
	Sadness	2.0	5.0	13.1	11.3	**81.9**	113.3	31.4
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		23.7	41.9	24.0	40.6	18.1		

10.5 Faces		**Depicted**						
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Total label use**	**False positives**
Perceived on the facial task	**Anger**	**78.8**	5.6	6.9	1.3	2.5	95.1	16.3
	Disgust	8.1	**92.5**	6.3	0.0	7.5	114.4	21.9
	Fear	10.6	0.0	**84.4**	0.0	8.1	103.1	18.7
	Happiness	0.6	1.3	1.2	**98.1**	0.6	101.8	3.7
	Sadness	1.9	0.6	1.2	0.6	**81.3**	85.6	4.3
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		21.2	7.5	15.6	1.9	18.7		

10.6 Gestures		**Depicted**						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Perceived on the gestural task	Anger	**81.9**	4.4	0.6	20.6	1.9	109.4	27.5
	Disgust	8.7	**56.9**	11.9	1.3	3.1	81.9	25.0
	Fear	1.3	8.1	**83.1**	0.6	12.5	105.6	22.5
	Happiness	3.7	10.0	0.6	**74.4**	0.0	88.7	14.3
	Sadness	4.4	20.6	3.8	3.1	**82.5**	114.4	31.9
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		18.1	43.1	16.9	25.6	17.5		

Confusion analysis is summarised in the following sections.

10.3.2b (i) False positives

The false positives between the three tasks were compared. There was a main effect of emotion, $F_{(4,180)} = 5.97$, $p<0.001$. There was an effect of task, $F_{(2,45)} = 11.00$, $p<0.001$. This reflects the higher accuracy rates on the facial task in relation to the vocal and gestural tasks. No significant emotion by task interaction can be reported, $F(4,180) = 1.42$, $p=0.192$. This suggests that number of times particular labels were used for vocal, facial, and gestural displays did not differ between tasks.

10.3.2b (ii) Responses when anger was represented

There was a main effect of emotion, $F_{(1.76,\ 79.10)} = 7.73$, $p<0.005$. Task did not have a significant effect, $F_{(2,45)} = 0.43$, $p=0.655$. There was a task by emotion interaction, $F_{(1.76,\ 79.10)} = 3.29$, $p<0.05$.

Participants mistook anger for fear on the facial task more than during the vocal task, $t(18.99) = -3.79$, $p<0.005$. They also mistook anger for happiness in the vocal task more than the facial task, $t(18.50) = 2.60$, $p<0.05$. Anger was also more regularly confused with fear on the facial task than the gestural task, $t(18.99) = 3.79$, $p<0.005$. The responses did not differ for other emotional labels when anger was depicted in the vocal, facial, and gestural tasks, $p>0.11$.

Generally, anger representations are mistaken for fear, except when anger is expressed in the face. Angry voices are misread as happiness more often than angry faces.

10.3.2b (iii) Responses when disgust was represented

A main effect of emotion was not revealed when disgust was represented, $F_{(3,135)}$ = 1.31, p=0.274. There was a significant effect of task, $F_{(2,45)}$ = 20.04, p<0.001, and this was qualified by a significant emotion by task interaction, $F_{(3,135)}$ = 5.41, p<0.001.

Vocal disgust representations were more likely to be confused with all other emotions than facial disgust representations: anger, t(30) = 2.83, p<0.01; fear, t(15.00) = 3.60, p<0.005; happiness, t(18.84) = 2.24, p<0.05; sadness, t(19.58) = 2.57, p<0.05. This reflects the significantly lower accuracy rate for vocal disgust. This is also paralleled in the gesture task, since disgusted gestures are more confused with all other emotions, except anger (p>0.6), in comparison to facial disgust: fear, t(15.00) = -3.11, p<0.01; happiness, t(16.46) = -2.21, p<0.05; sadness, t(15.60) = -4.48, p<0.001. Vocal disgust is mistaken for anger more than gestural disgust, t(30) = 3.26, p<0.005. By contrast, gestural disgust is more commonly mistaken for sadness than vocal disgust, t(18.77) = -3.23, p<0.005. All other comparisons across tasks were not significant, p>0.49.

Facial disgust is rarely confused with other emotions, whereas vocal and gestural representations of disgust are poorly recognised and confused with a range of emotions. The confusions over disgust depend on modality of portrayal, thus, participants confuse vocal disgust for anger more than gestural disgust, and gestural disgust is mistaken for sadness more than vocal disgust.

10.3.2b (iv) Responses when fear was represented

There was a significant effect of emotion, $F_{(2.51,\ 112.76)}$ = 4.87, p<0.01. Task did not have an effect, $F_{(2,45)}$ = 1.18, p=0.318. A significant interaction between task and emotion was observed, $F_{(2.51,\ 112.76)}$ = 5.85, p<0.001.

Happiness was more commonly used to label vocal representations of fear than facial fear, t(23.06) = 2.09, p<0.05, and gestural fear, t(19.58) = 2.57, p<0.05. Fearful vocalisations were also described as resembling sadness more than facial fear, t(16.78) = 3.29, p<0.005, and gestural fear, t(20.65) = 2.45, p<0.05. By contrast, gestural representations of fear were labelled as disgust more often than vocal fear,

$t(30) = -2.57$, $p<0.05$. There were no differences between responses to the gestural and facial fear depictions, or any other comparisons, $p>0.088$.

In summary, fear in the voice is confused with happiness and sadness. This was less true for facial and gestural expressions of fear. Fearful body movements are more likely to be mistaken for disgust in comparison to fearful vocalisations.

10.3.2b (v) Responses when happiness was represented

Analysis of the responses to happiness representations revealed a main effect of emotion, $F_{(2.37, 106.47)} = 5.40$, $p<0.005$. A main effect of task, $F_{(2,45)} = 25.58$, $p<0.001$, and a significant emotion and task interaction, $F_{(2.37, 106.47)} = 8.72$, $p<0.001$, were revealed.

Differences in confusions for happiness between the tasks are expected due to the higher recognition accuracy rates for facial happiness. Indeed, happy vocalisations are consistently more confused with all other emotions, except anger ($p>0.098$), than facial happiness: disgust, $t(15.00) = 3.22$, $p<0.01$; fear, $t(15.00) = 6.82$, $p<0.001$; sadness, $t(15.83) = 2.80$, $p<0.05$. Furthermore, the vocal happiness is mistaken for disgust, $t(18.97) = 2.52$, $p<0.05$, and fear, $t(17.86) = 6.22$, $p<0.001$, more than gestural happiness. By contrast, gestural happiness is more commonly confused with anger than vocal happiness, $t(30) = -2.89$, $p<0.01$. Moreover, participants generally mistook gestural happiness for anger more than facial happiness, $t(18,37) = -4.97$, $p<0.001$. All other comparisons were not significant, $p>0.06$.

Facial happiness attains high accuracy levels, so in comparison to the vocal task, it is less confused with other emotions. Generally, happy vocalisations were mistaken for disgust and fear more than happy gestures and happy faces. Happy gestures are commonly described as angry in contrast with the other channels.

10.3.2b (vi) Responses when sadness was represented

Analysis of the responses to sadness representations revealed a main effect of emotion, $F_{(2.11, 94.72)} = 14.97$, $p<0.001$. The tasks were not significantly different, $F_{(2,45)} = 0.04$, $p=0.962$. There was a significant task by emotion interaction, $F_{(2.11, 94.72)} = 3.37$, $p<0.05$.

The responses to facial portrayals of sadness did not differ from responses to vocal or gestural sadness: vocal, all $p>0.10$; gestural, all $p>0.12$. Participants confused sad vocalisations with disgust more than sad gestures, $t(23.00) = 2.19$, $p<0.05$. In contrast, the sad gestures were commonly mistaken for fear more than the vocalisations, $t(30) = -2.67$, $p<0.05$. All other comparisons were not significant, $p>0.083$.

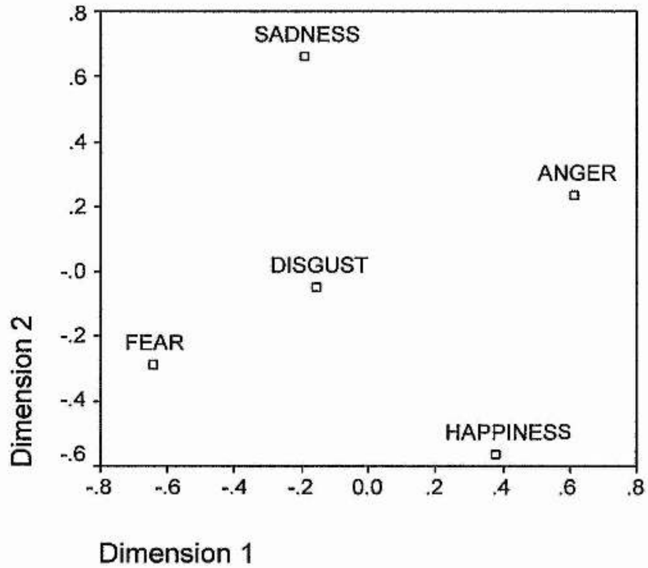
Gestural and vocal sadness were confused with the same emotions as facial sadness. Sad vocal cues were more often mistaken for disgust than sad gestures, which were readily misinterpreted as fear.

10.3.2c Multidimensional scaling

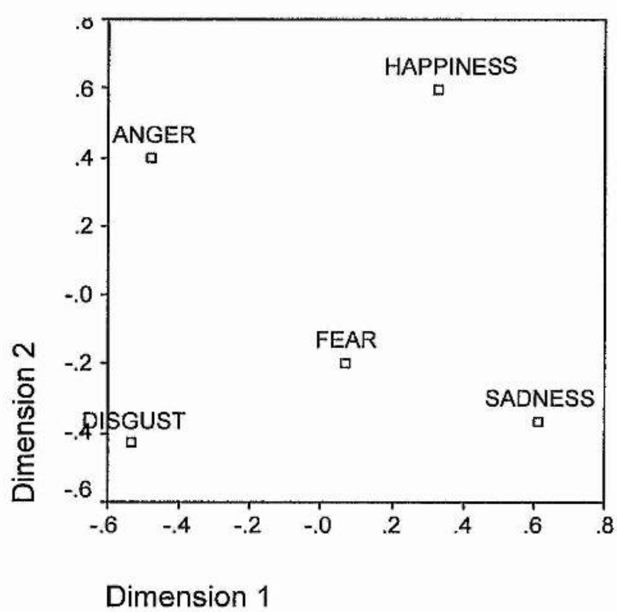
In order to visually demonstrate the differing relationships between emotions from the three channels, multidimensional scaling was carried out. The multidimensional scaling procedure enables a geometric representation of the relationships between different emotions. The PROXSCAL algorithm was used. To obtain the input for this algorithm, the 5 by 5 confusion matrices from each of the emotion tasks were converted to distances, by subtracting the response rate from 100, then averaging these distances across the diagonal. This enables those emotions that are most confused with each other to have smaller distances from one another than those that are not easily confused. Multi-dimensional analysis by SPSS was then carried out on these new tables. See Kruskal and Wish (1978) and Pollick and colleagues (2001) for more information regarding this procedure. The results for the multidimensional scaling for each communication channel are displayed in Figures 10.4-10.6.

Figures 10.4-10.6: Psychological space for (10.4) gestural, (10.5) facial, and (10.6) vocal basic emotions.

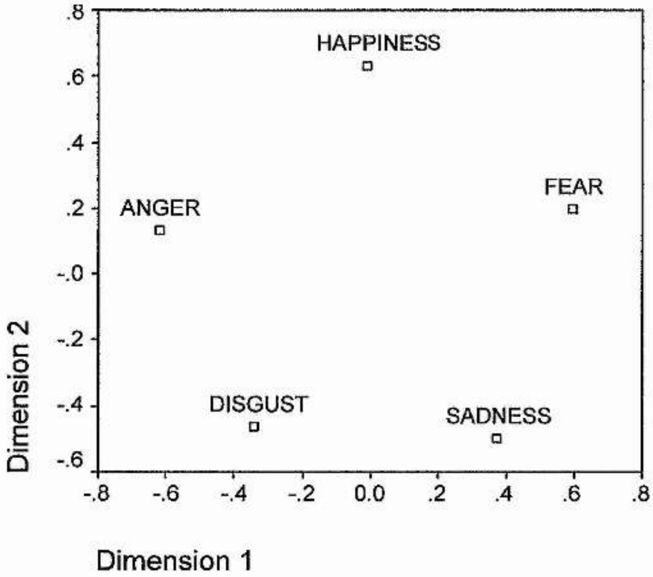
(10.4) Gestures



(10.5) Faces



(10.6) Voices



10.3.2d Summary

The present results reveal that emotions are recognised with different levels of ease dependent on the presentation condition. For instance, facial representations seem to be particularly important for accurate communication of disgust. Faces best express happiness, and voices express happiness least well. Generally, for anger, fear, and sadness the presentation condition does not seem to differentiate the ease of interpretation to a great extent. By contrast, the pattern of responses does vary between the tasks. Table 10.7 summarises the differences between tasks.

It is important to note that lower accuracy rates for vocal disgust and happiness, and gestural happiness, in comparison to the facial channel may explain several of the differences in confusion summarised in Table 10.7.

Table 10.7: Strength of confusions made in different channels of communication
Voc = voices Fac = faces Ges = gestures

$*p<0.05$ $**p<0.01$ $^{\#}p<0.005$ $^{\#\#}p<0.001$

		Depicted				
		Anger	**Disgust**	**Fear**	**Happiness**	**Sadness**
Perceived	**Anger**	**n.s.**	Voc>Fac**	n.s.	Ges>Voc* Ges>Fac$^{\#\#}$	n.s.
	Disgust	n.s.	**Fac>Voc$^{\#\#}$** **Fac>Ges$^{\#\#}$**	Ges>Voc*	Voc>Fac** Voc>Ges*	Voc>Ges*
	Fear	Fac>Voc$^{\#}$ Fac>Ges$^{\#}$	Voc>Fac$^{\#}$ Ges>Fac**	**n.s.**	Voc>Fac$^{\#\#}$ Voc>Ges$^{\#\#}$	Ges>Voc*
	Happiness	Voc>Fac*	Voc>Fac* Ges>Fac*	Voc>Fac* Voc>Ges*	**Fac>Voc$^{\#\#}$** **Fac>Ges$^{\#\#}$** **Ges>Voc*** **Fac>Ges>Voc**	n.s.
	Sadness	n.s.	Voc>Fac* Ges>Fac$^{\#\#}$ Ges>Voc$^{\#}$ **Ges>Voc>Fac**	Voc>Fac$^{\#}$ Voc>Ges*	Voc>Fac*	**n.s.**

The results seem to indicate that anger representations tend to be confused with disgust across all modalities. Angry faces tend to be mistaken as fearful far more often than angry voices and angry gestures. Angry voices are also commonly confused with happy voices, a mistake that is not as regularly made in the facial task.

Fearful representations are interpreted as disgust across modalities, yet this occurs more often in the gesture task than in the vocal channel. Fearful voices are perceived as sad or happy, and these emotions are not as often confused in the two visual tasks.

Sad expressions are often confused with fearful expressions and this seems to occur more in the gestural task than the vocal task. Sadness is also interpreted as disgust, and this occurs more in the vocal task than the gestural task. Thus, it seems that channel of emotional representation does seem to influence the labelling responses for particular emotions. Emotions are not always confused with the same emotions across channels. This makes it particularly difficult to create a general model of emotion.

10.4 General discussion

The present research has demonstrated that the facial channel is not the most salient means of communication for all emotions. Indeed sadness, anger, and fear are just as readily communicated in the vocal and gestural channels as the facial channel. This indicates that studies examining the perception of emotion from purely the facial channel are not necessarily measuring recognition accuracy for cues which are the most accurate representations of that emotion.

The ease of recognition for happiness and disgust from the facial channel as opposed to other channels could reflect their phylogenetic origins. In other words, each emotion has evolved for some functional purpose, which determines the communication channel that emotion is best expressed in. For more information, please see Section 11.3.3b.

Furthermore, this study has revealed that the relationship between emotions depends on the communication channel in which they are expressed. The same emotions are not confused across modes of display. The results from the multidimensional scaling task contrast with other studies that have employed this or a similar technique with different modes of emotional expressions (Coulson, 2004; Green & Cliff, 1975; Russell, 1980); this could reflect different stimuli employed and/or different population groups.

Happiness is readily recognised from facial expressions; this may, in part, be because it is the only positive facial emotion of the group defined by Ekman and Friesen (1971). The lack of other positive emotions depicted by facial expressions seems to be confounded by the fact that positive emotions are carried universally by a smile. As a consequence, emotion research assumes that happiness/positive affect is one homogeneous category. Interestingly, Scott and Sauter (2004) have shown that this might not be the case, since numerous positive vocal emotions (achievement/triumph, amusement, contentment, sensual pleasure, relief) can be distinguished and recognised across populations and cultures. Thus, it seems that different communication channels are better equipped for conveying specific emotions, and that basic emotions might be divided further dependent on the mode of communication.

The present study fails to account for the interaction between several types of information being communicated. Such emotion tasks represent artificially simulated situations. Given that emotions are rarely expressed in isolation, it is difficult to extrapolate the relative contributions of each channel when they are not combined.

Despite this, the present study has provided evidence for dissimilarities between emotions represented in different channels of communication and this may reflect phylogeny. It is important to note that the face is not necessarily the best means to communicate particular emotions. Proximity may play a role in the development of emotional signals, since particular states might require to be communicated across distances, and facial cues are not ideal for this purpose.

11 CONCLUSIONS

This closing chapter will review the experiments presented in this thesis and will discuss the findings in terms of their implications for methods employed and conclusions drawn in recent and future emotion research.

11.1 Introduction

Understanding the complexity of neural mechanisms involved in emotion processing is important for appreciating how evolution may have shaped the brain for social communication. With the emergence of research indicating face specific neurons within the brain (Perrett, Rolls, & Caan, 1982; Perrett et al., 1984) and a dissociation between perception of emotion and identity from the face (Etcoff, 1984; Hasselmo et al., 1989; Tranel et al., 1988; Young et al., 1986), researchers have sought to identify whether a unified model can account for emotion processing. Extensive neuropsychological and imaging research (described in Section 1.5.2) contends strongly for neural systems that are specialised for processing specific emotions. Yet research is inconclusive regarding whether the same neural regions process facial emotion as vocal or gestural emotion. Conclusions from many emotion investigations cannot be generalised to wider populations, given that such studies often assume (perhaps incorrectly as demonstrated in Chapter 10) that the face is the most salient cue for communicating all emotions. The research outlined in this thesis has used different forms of emotional expression with clinical and non-clinical populations, in order to compare and contrast the processes that may be involved in emotion perception from different communication channels. Furthermore, neuropsychological research has neglected differences that may influence emotion processing abilities, such as mood, age, and sex. This has also been addressed in a series of studies.

11.2 Synopsis of findings

The research described in this thesis has produced a number of intriguing findings in relation to the processing of emotions from multiple communication channels, and with regard to individual differences.

11.2.1 Difficulties in disgust recognition with mood

Chapter 3 indicated that people with positive mood traits *and* negative mood traits are less able to recognise disgust represented by body movements. In accordance, Chapter 4 suggests that negative mood states interfere in disgust processing from vocal cues. It is of interest to note that supplementary analysis in Chapter 9 also suggests that depressed moods might lead to greater difficulties in perceiving disgust from faces. This finding corresponds with research carried out by Murray (2000), who also reported a deficit in disgusted face perception as a consequence of clinical and non-clinical depression (measured by the Beck Depression Inventory -BDI). The studies presented in this thesis suggest that negative moods can be associated with interpretative problems with disgust. A fundamental oversight of the present research, however, is that different mood measures (Positive and Negative Affect Schedule – PANAS - and Hospital Anxiety and Depression Scale - HADS) and different emotional stimuli (gestures and voices) have been incorporated into each study, so the extent to which each may be related is unclear. While it is unlikely that dysphoria, as measured by the PANAS, *only* affects perception of gestural disgust, and dysphoria, as measured by the HADS, *only* has an influence on the recognition of disgust represented by vocalisations, and dysphoria, as measured by the BDI, *only* impacts on the interpretation of facial disgust, this cannot be ruled out as a possibility. Watson and colleagues (1988) demonstrated that the BDI correlates positively with the negative affect scale of the PANAS (0.6). In addition, the depression subscale of the HADS also correlates (0.6) with the BDI (Beck, Guth, Steer, & Ball, 1997). This suggests that measures of dysphoria, calculated using these three scales, are related.

The basis for impairment in disgust processing in dysphoria is not established. Initially, it had been posited that moods impact on the interpretation of the least discrete or least readily identifiable stimuli, since vocal and gestural disgust are the most difficult emotions to classify by all participants. Yet the potential association between dysphoria and facial disgust perception suggests that this may not be the case, since disgust is relatively well-recognised in comparison to other emotions from the face. Indeed, this indicates that the problem may be more specific to disgust processing in itself, which, in turn, could be used as an argument for specificity of neural regions underlying the perception of disgust. Direct implications of these findings for clinical research will be discussed in Section 11.3.1.

Symptoms of dysphoria are not explicably related to disgust or dysfunctional experiences in disgust perception. This emotion, regardless of channel, was more confused with sadness by dysphoric groups than non-dysphoric participants. Thus, it is plausible that people with negative moods have a bias to respond with the label sadness, and this represents a disturbance in the processing of sadness, rather than disgust. Indeed, clinical and non-clinical research have often suggested that people with depressed moods are more likely to perceive or remember sadness, in contrast to other emotions (Mandal & Bhattacharya, 1985; Niedenthal et al., 2000; Ridout et al., 2003). According to Woodworth and Schlosberg's (1954) model of emotional space, disgust and sadness are more closely related to each other than other emotions. Sad faces can be perceived as disgusted when context is manipulated (Carroll & Russell, 1996). So, perchance, dysphoric mood may enhance the confusion between these two emotions.

The idea that elevated disgust sensitivity is at the root of this perceptual disturbance should not be discarded, however. Recognition for expressions of disgust may be related to implicit understanding of the concept of disgust (Rozin et al., 2000). So, perhaps people who experience disgust more often than others, have an atypical understanding of this emotion, and this is reflected in a difficulty in perceiving disgust from nonverbal cues (for more information, see Sprengelmeyer and colleagues, 1997). Future extensions of the present work may consider including a measure for disgust sensitivity, as well as testing the impact of moods (using one unified measure) on the perception of facial, vocal, *and* gestural emotion.

11.2.2 Sex-congruent recognition of fear

The influence of sex is often investigated in emotion research, but studies have rarely explored the relationship between sex of actors and sex of perceivers. Sex-congruent findings for the perception of vocal fear were reported in Chapter 6. It was indicated that men interpreted male renditions of fear more readily than women did, and women perceived female fear more readily than men. Social learning and different experiences of men and women might account for this disparity. For instance, men tend to fight – playfully and seriously – with other men, and women are more inclined to fight with women. Male-female fights are much rarer (Goos & Silverman, 2002). Since aggressive situations, like fights, often lead to fearful responses, men should be more familiar with observing other men feeling fearful, and women should be more exposed to other women experiencing fear. Familiarity and experience are predicted to enhance recognition of such cues, according to sociocognitive research (Blanchard-Fields, 1996). Therefore, considering this approach, men should be better at interpreting male fear, and women should be better at recognising female fear.

Additionally, neural systems associated with mirroring may well be involved in the perception of these vocal cues. Executing, observing, and imagining particular gestures all activate the same neural regions (see Section 1.5.4 for more information), and this has led researchers to suggest that in order to interpret social cues of others, we may map their movements/gestures onto mental representations, which enables us to simulate how they may be acting/feeling. Familiarity has been shown to hasten neural processing and interpretation of movements (Grèzes et al., 2004), thus, familiarity with emotional expressions might improve their recognition. Should men and women express fear in fundamentally different ways, then perhaps mirror neurons are involved in the sex-congruent advantage in perception of vocal fear.

A combination of these two approaches could best account for the present pattern of responses.

11.2.3 Gestural and vocal emotion recognition disturbed with ageing

In order to explore the relationship between different channels of emotional communication, recognition accuracy was assessed on a number of emotion tasks in two age groups, as described in Chapter 8. Research exploring ageing populations and emotion perception has been inconsistent. The present results revealed that there was no clear pattern of impairments across modalities or across channels of communication. Most emotional gestures in full-light and point-light conditions were more challenging for older participants to interpret than a younger group, with the exception of full-light dynamic fear. Generally, the older participants also had difficulties in recognising vocal emotion – both nonsense and, to a lesser extent, verbal. By contrast, there were no differences between the two age groups in their perception of facial emotion.

This task specificity might reflect the existence of independent neural substrates for the processing of particular emotions represented by different modalities and task conditions. Alternatively, there may be separable pathways for the processing of dynamic emotional information that are impacted by ageing. Thus, age could impact most deleteriously on neural systems underlying vocal and gestural processing of emotion. Alternatively, emotion processing from voices and gestures tends to be more difficult than from faces (see Chapter 10), so it is plausible that ageing disturbs recognition for stimuli that are most challenging to interpret.

If each emotion was processed by a specialised neural substrate, regardless of modality of presented, then any difficulties in the interpretation of a particular emotion should have been observed in all tasks. By contrast, if there were one integrated mechanism for the processing of emotion, which is affected by ageing, then recognition accuracy levels on all tasks should be affected to the same degree. Neither of these stances was substantiated by the present data.

Older people are frequently reported to have disturbed recognition accuracy for sadness (Calder et al., 2003; MacPherson et al., submitted; Moreno et al., 1993; Phillips & Allen, in press; Phillips, MacLean et al., 2002). Difficulties in perceiving sadness have been attributed to the view that older individuals involved in psychological testing are happier than younger people (Lawton, 2001; Lawton et al., 1992), and are less familiar with sad expressions. Perhaps disturbed sadness perception was reflected in the present research in older people's over-use of the label sadness to describe negative stimuli which are not readily identifiable (please see Appendix 3). This does not account for the inconsistencies between the results for facial emotion tasks with ageing populations in different studies.

With respect to the present data and the population group explored, ageing does not seem to impact on emotion-specific modules within the brain that are supra-modal in nature. Nevertheless, it should not be forgotten that the neurological deterioration associated with ageing is not selective in nature, nor is such deterioration likely to occur at the same rate or even be universal for all older people, therefore conclusions regarding neural specificity are limited from such a study.

11.2.4 Vocal emotion recognition and Parkinson's disease

Other than characteristic movement difficulties, Parkinson's disease is typified by a lack of facial and vocal emotional expression. Research on mirror systems suggests that neural control of expressive actions is related to the perception and imagination of such actions. See Section 1.5.4 for more information. Researchers propose that interpretation of others' actions, and intentions involve multi-modal mirror systems, mapping of such gestures onto our own mental representations of these movements. Since motor and emotional expression and mental imagery is reduced in Parkinson's disease, Chapter 9 comprises a study exploring emotion perception from dynamic and still channels in Parkinson's patients.

Contrary to predictions, emotions conveyed by body movements were recognised with ease by the Parkinson's patients, yet perception of all vocal emotions was disturbed in this group in comparison to control participants. A series of comprehensive tasks suggest that recognition of emotions represented by the face is also unimpaired. This suggests that Parkinson's disease does not impact mirror systems. This will be discussed further in Section 11.3.2.

That the Parkinson's group find the vocal emotion recognition task particularly problematic could imply that neural substrates for processing vocal emotion are disturbed by Parkinson's. Alternatively, this could reflect a more central impairment in sentence and language processing, which is often observed in Parkinson's disease (Grossman et al., 1991; Lieberman, Friedman, & Feldman, 1990). Two positions try to account for this general language difficulty: some associate the impairment with a grammatical deficit (Lieberman et al., 1992); others attribute the problem to limited cognitive resources involving frontal-striatal-thalamic loop (Grossman et al., 2003; Grossman et al., 2002; Lee, Grossman, Morris, Stern, & Hurtig, 2003). Regardless of how the sentence comprehension deficit arises, fundamentally, this impairment could explain the lower accuracy rates attained by the Parkinson's group on the vocal emotion task, in comparison to control participants. To test if the problem is specific to prosody, Parkinson's patients' abilities at interpreting nonverbal vocal emotion stimuli, such as screams, laughter, and so on, could be examined in conjunction with the verbal prosody task.

When surprise was included as a response choice and stimulus in a facial task, the Parkinson's group used the surprise label more than the control group, particularly for mislabelling fearful faces. Control participants also make this mistake regularly though. Another study has associated Parkinson's disease with an elevated sensitivity or perhaps response bias to perceiving surprise (Dujardin et al., 2004). This indicates that the processing and experience of surprise may be dysfunctional in Parkinson's disease. Parkinson's disease might influence neural systems specialised for the processing of surprise. Alternatively, since fear is much less commonly displayed in social interactions, perhaps illness-related experiences have rendered Parkinson's patients more susceptible to observing surprise in social situations than control participants. Future research could address this problem by presenting an emotion perception task in which target emotions are morphed with surprise at different proportions and participants are asked to indicate to what extent surprise and the target emotion are incorporated in each image.

11.3 Implications for emotion research

Combined, the conclusions drawn from the studies in this thesis suggest that various aspects of neuropsychological emotion research need to be addressed. The findings have a bearing on theories of neural organisation of emotion, and further understanding is provided for the structure and relationship between emotions.

11.3.1 Caveats for emotion perception research

The initial mood study revealed that both negative and positive moods have an effect on emotion recognition rates. Thus, the importance of monitoring both negative *and* positive affectivity should be stressed. Studies that have shown little or no influence of mood on perceptual abilities may well reflect the grouping of people with positive moods in a generic control group. Moods are rarely monitored in perception research, and it is worth considering the impact they may have on other perceptual abilities.

Difficulties in disgust perception have often been attributed to basal ganglia dysfunction in illnesses such as Huntington's and Parkinson's disease (Gray et al., 1997; Kan et al., 2002; Sprengelmeyer et al., 1996; Sprengelmeyer et al., 2003; Sprengelmeyer, Young, Pundt et al., 1997; Wang et al., 2003; Yip et al., 2003). Further analysis of some of these studies suggests that emotions other than disgust are impaired in these populations (Milders et al., 2003). While basal ganglia are highly inter-connected with the insula cortex, imaging research (Heining, 2003; Heining et al., 2003; Phillips, Young et al., 1998; Phillips et al., 1997; Sprengelmeyer et al., 1998) and convincing neuropsychological case studies of two patients with insula cortex damage (Adolphs et al., 2003; Calder, Keane, Manes et al., 2000), seem to suggest that the insula cortex is a more credible candidate for a neural system selectively processing disgust. For instance, disgust deficits observed in studies of Huntington's disease and Parkinson's disease might be indicative of the mutual connections between the insula and basal ganglia. Alternatively, it could reflect incidence of depression in particular disorders. The present research seems to signify that dysphoric moods diminish the ability to interpret disgusted faces, voices, and gestures correctly – thus, this should be taken into account when carrying out neuropsychological research. Disgusted gestures and voices were confused with sadness (analysis was not carried out on confusions for disgusted faces by participants in Chapter 9, although sadness and anger are typically used for disgusted faces by these participants).

Future research should monitor mood levels in Huntington's and Parkinson's populations, as variations in moods and correlations between dysphoria and disgust recognition levels could explain inconsistencies in research looking at these groups. Dysphoria may be a defining feature of a disgust deficit.

A major caveat for neuropsychological research in the design of emotion tasks has been highlighted. The Parkinson's disease study in Chapter 9 demonstrated that apparent deficits in recognition of facial fear disappeared when the task was adapted to exclude expressions of surprise. This was the case for both the Parkinson's patients and the control population. If a problem in the recognition of the emotion of fear did exist, then such a change to the design should not improve recognition accuracy levels. It seems a response pattern developed whereby participants consistently mistook fear for surprise, and given the relationship and similarities between the two facial states, this is perhaps to be anticipated. Inclusion of surprise could falsely generate impairments in fear recognition in patient populations. Consequently, when recognition of facial fear is reported to be impaired in certain populations, it is imperative that researchers scrutinize the design of their task before suggesting that these populations have a deficit specific to fear recognition.

11.3.2 Implications for the neural organisation of emotion processing

Neuropsychological research is based on the premise that to understand how the brain functions, we need to observe which faculties are disrupted when particular neural regions are damaged. A complication with this notion is that brain damage is rarely selective, and it can be difficult to understand which neural regions relate to which function, and which involve neural overlap. The research in this thesis has facilitated discussion regarding the particular neural regions responsible for processing emotion from multiple communication channels.

Emotion perception involves interpreting cues from a number of channels, including facial expressions, vocal expression, body movements, postures, vocal content, and so on. Yet much neuropsychological and imaging research exploring emotion processing has been restricted to studies of facial emotion. The study in Chapter 10 has shown that the face does not best convey certain emotions. Thus, emotions communicated by the face do not represent 'emotion' as a whole construct. Some neuropsychological and imaging research studies have also examined perception of vocal emotion, yet studies that have explored both vocal and facial emotion are largely inconsistent (see Section 1.5.3). Some researchers posit that emotions have evolved for some functional purpose, such as detection of threat, which would not operate only in one modality; therefore, neural regions would process specific emotions, regardless of the presentation form of the emotional expression.

An ideal way to test this idea is to examine the emotion perception abilities (from a number of channels) of populations with signs of neurological deterioration to centres thought to play a role in emotion processing. Dopaminergic systems and regions of the striatum have been implicated in anger (Lawrence et al., 2002) and disgust processing respectively (Sprengelmeyer et al., 1996; Sprengelmeyer, Young, Sprengelmeyer et al., 1997). Both neural systems are affected in Parkinson's disease. The exploration of emotion recognition in Parkinson's patients, described in Chapter 9, suggests that the mode of presentation is important in terms of the recognition accuracy rates for specific emotions. This indicates that Parkinson's disease might have a bearing on independent neural mechanisms that underlie perception of emotions represented in particular modalities. Furthermore, research examining the impact of ageing on emotion recognition indicates that even within modalities, a consistent pattern of impairments does not exist (Chapter 8). Ageing and Parkinson's disease, therefore, do not impact on systems processing specific emotions or all emotions. For instance, anger recognition from faces, point-light gestures, nonsense vocalisations was unaffected by ageing, whereas anger recognition from the full-light gestures and the verbal vocalisations was impacted. Also, fear recognition was disturbed by Parkinson's disease in the verbal emotion task, but not in the full-light gestural or the facial tasks (excluding surprise). Both ageing and Parkinson's disease are not characterised by selective neural disruption, however, and so it is plausible that degeneration of peripheral systems involved in perception may explain the present results.

As discussed earlier, there is converging imaging and neuropsychological evidence for a neural system responsible for processing disgust, from many sensory inputs, particularly, those of smell, touch, taste, and vision (Adolphs et al., 2003; Calder et al., 2003; Heining, 2003; Heining et al., 2003; Phillips et al., 2000; Phillips et al., 2004; Phillips, Young et al., 1998; Sprengelmeyer et al., 1998; Wicker et al., 2003). The findings from these studies provide a cogent argument for a role of the insula cortex in the perception and experience of this emotion. The research in this thesis corresponds with this proposal, since it indicates an association between dysphoria and the perception of disgust from multiple channels.

In addition, the implications of the present research for understanding mirror systems are unclear. This clinical study emphasises that intact motor control is not vital for the perception of emotion depicted by movements. Nevertheless, it should be noted that motor control is not disturbed at a cortical level in Parkinson's disease, which suggests that cortical mirror systems are also intact in this illness.

11.3.3 The relationships between channels of communication

11.3.3a The structure of emotions

The clinical and non-clinical studies exploring multi-channel emotion perception that are described in this thesis demonstrate that emotions are recognised less easily through certain channels of communication than others. For instance, in a normal, healthy population, happiness is recognised with comparative ease from facial displays, yet gestural and vocal happiness are more challenging to interpret. Disgust representations have this pattern too. Should emotion, as a whole, be structured in one unifying model, or with specific modules per emotion, it would be hypothesised that emotions might be recognised at the same relative rate across different modalities.

This is not the case. Dissociations of performance between modalities enlighten our understanding of the organisation of emotions.

Two main theories contest how emotions are structured: dimensional and categorical accounts of emotion. Should emotions be part of a general space, specific dimensions would define the differences between them. The dimensional approach to emotions attempts to provide a comprehensive explanation for the relationships between emotions. The analysis of errors in the present research has revealed that the emotions that are most commonly confused differ depending on the channel of communication. This suggests that the circumplex model (Russell, 1980; Woodworth & Schlosberg, 1954), which has emerged from dimensional accounts of emotion, is dissimilar for facial, vocal, and gestural emotion.

Indeed, many of the dimensional models have been derived from studies comparing similarity between facial expressions of emotion (Cliff & Young, 1968; Green & Cliff, 1975; Royal & Hays, 1959; Shepard, 1962) or emotional labels (Bush, 1973; Neufeld, 1975; Russell, 1978; Russell & Mehrabian, 1977). Some studies endeavouring to build a model on the basis of vocal emotion research have outlined similar models to those derived from facial emotion, but there have been some anomalies, such as grief being regarded as more pleasant than indifference (Davitz, 1964; Dawes & Kramer, 1966; Green & Cliff, 1975; Smets, 1967). Consequently, dimensional models of vocal emotion have not been sufficiently determined.

Since emotional expressions seem to have fundamentally distinct responses and different functional purposes, another school of thought proposes that emotions are categorical: that there are distinct perceptual shifts in recognising each emotion. This stance is often associated with arguments for distinct neural mechanisms for each emotion. This view, as mentioned in Section 11.3.2, is not wholly supported by the present research.

The categorical account of emotions has been supported behaviourally by the work of Calder and colleagues (1996) and Etcoff and Magee (1992), as described in Section 1.2.2, whereby there is a specific stage, a specific combination of two morphed emotions, when the observers conclude that a face no longer represents one emotion, but the other. Should emotion perception be dimensional, the perceived change from one emotion to another should be a gradual process.

Whether vocal emotions or gestural emotions would involve the same shift in perception is yet to be substantiated. Morphing vocal and gestural emotion would be much more difficult than morphing a static percept, yet there is considerable scope for manipulating voices along a continuum. DeGelder and Vroomen (2000) created vocal morphs from happiness to fear in a research study exploring the influences of facial emotion on the recognition of vocal emotion and vice versa. If this technique could be developed further, and voices morphed between all emotion combinations, it might be possible to examine whether categorical shifts in vocal emotion interpretation exist.

Interestingly, Scott and Sauter (2004) suggested that an array of positive emotions, other than the generic 'happiness' exist, but these are distinguished in modalities other than the face, since all positive emotions are carried by smiles facially. Positive emotions conveyed by voices include achievement/triumph, amusement, contentment, sensual pleasure, and relief. All can be distinguished with relative ease across different cultural populations. This indicates that perhaps basic emotions may differ between modalities, which further indicates independence of the neural underpinnings for vocal and facial emotion at least.

In summary, the dimensional account for the structure of emotions is challenged by the present research on confusions and difficulty levels. The categorical explanation for the structure of emotions only applies to facial emotion, at present. Future work could examine whether this model can be extended to vocal or gestural emotion as well.

11.3.3b Disparities between channels of communications

This thesis has shown that certain emotions are better interpreted from particular channels of communication. The face may not be the most reliable cue to a person's emotional state. Evolutionary constraints and the functional purpose of each emotion may determine that specific emotions might be displayed most clearly through particular channels of communication. For instance, disgust is postulated to have evolved as a rejection response to bad tastes, to protect oneself and act as a warning to one's offspring from ingesting potentially poisonous stimuli (Rozin et al., 2000). If this were the case, disgust would not necessarily need to be conveyed across distances. Facial expressions are the most apparent means to communicate warnings within a short distance. Furthermore, disgust does not appear to be associated with any easily decipherable *natural* body gestures (Coulson, 2004; De Meijer, 1989; Heberlein et al., in press; Walk & Homan, 1984). This emotion is also associated with physical repulsion and nausea; retching makes a strong sound itself, so vocalisations might be hindered. Compliant with the current findings, disgust does not appear to have a consistent and distinct vocal profile (Banse & Scherer, 1996; Scherer, 1986; Van Bezooijen et al., 1983). Moreover, happiness is thought to represent camaraderie, so again this emotion would be best expressed in close proximity. Therefore, facial expressions would be an ideal means for communicating this sentiment.

The channels through which certain emotions are least well represented are also those in which recognition accuracy is most affected by mood (disgusted gestures and voices) and ageing. This supports the idea of a 'first-in, last-out' hypothesis, as proposed in Chapter 8, which states that regular, well-practised abilities will be relatively preserved, despite neural degeneration or disturbance.

This proposal might also be closely linked to theories that task difficulty is exacerbated in populations experiencing some form of neurological deterioration (Rapcsak et al., 2000). Moreover, as outlined in Chapters 9 and 10, task difficulty can be enhanced by methodological manipulations: the design of the facial task dictated where difficulties in perception abilities would lie, and these difficulties were exacerbated in a patient group.

11.3.3c Surprise – a caution

The omission of surprise in the facial emotion task was contentious. The Ekman 60 has been used in multiple research studies cross-culturally and across the decades and highlighting a potential flaw in its design could have considerable repercussions.

According to Ekman (1999), the key characteristics that determine a basic emotion are distinctive universal signals (facial, vocal, gestural, and so on), emotion-specific physiology, automatic appraisal mechanisms, universal antecedent events. It is particularly interesting then, that surprise lacks specific autonomic nervous system activity (Ekman, Levenson, & Friesen, 1983) and a discrete vocal signal (Murray & Arnott, 1993). The inclusion of surprise in a list of basic emotions has always been contentious (Ortony & Turner, 1990). For instance, surprise lacks valence – it can be described as neither positive nor negative, unlike other emotions. It is a more transient state that precedes other emotions, such as happiness or fear, which it is often confused with. Moreover, in the creation of emotional tasks, surprise is often left out and the five basic emotions, as used in the present research, are focused on instead. It was noted in Ekman and colleagues (1969) cross-cultural research that fear was consistently confused with surprise, yet they still concluded that fear and surprise were distinct emotions.

While it is not possible on the basis of the present data to provide an irreproachable argument against the inclusion of surprise under the basic emotion umbrella term, it must be emphasised that the use of surprise in tests of facial expression recognition can be misleading, and may result in the emergence of a spurious impairment in the perception of fear.

11.3.4 Evaluation of the confusion analysis technique

An unusual statistical method for exploring emotion perception has been presented in this thesis. Most research studies examine absolute sensitivity levels, or participants are asked to rate emotional expressions on a number of scales. Many studies have discussed which emotions are consistently confused with others, particularly those studies that have developed the dimensional account of emotions. Yet few studies have completed analysis on confusions, except multidimensional scaling, which is a modelling function, rather than an exploration of statistical differences between groups.

The methods used to examine confusions are straightforward, and easy to apply. Exploration of responses is central to understanding where and why deficits occur. For instance, a particular population might achieve high accuracy rates for one emotion of five. This may be a vestige of a tendency to use that emotional label for most stimuli, in which case, researchers examining accuracy rates might conclude that this population have a deficit in perceiving all emotions except one, whereas confusion analysis would suggest that the population might have a problem with only one emotion instead.

In the present research, statistical evidence for a tendency to use the label surprise for facial representations of fear was presented, which was the fundamental to the rationale to drop surprise from the facial emotion task.

Incorporating an analysis of confusion into emotion research could be particularly enlightening and important for understanding the nature of emotional impairments.

11.4 Directions for future research

A number of questions have been raised by the present studies, not least regarding the methods employed in emotion research. Dissociations between results attained when testing emotion recognition using different channels of communication have been demonstrated. Generally, the primary conclusion of the research in this thesis is that multiple channels of communication should be incorporated into studies of 'emotion' per se, since the results of facial emotion tasks do not reflect emotion as a whole, and should not be generalised to other channels of communication. A complex pattern of neural organisation is consistent with these results. The findings support the stance that there are several overlapping systems for specific emotions represented in discrete communication channels. The mood and sex studies presented in this thesis also highlight the importance of measuring such characteristics in neuropsychological studies of emotion perception. Furthermore, the task design should be closely contemplated before neuropsychological assessment occurs, since the inclusion of misleading labels can give rise to the emergence of impairments that do not necessarily exist in other circumstances. Therefore, a number of suggestions for future research to incorporate have been presented.

11.5 Final note

A series of cautions for neuropsychological research have emerged, regarding variables to control for and to take into consideration. While the structure of emotions, both conceptually and neurologically, is still unclear, the present research provides a more complete but complex picture regarding the relationships between emotion and modalities. An effective method for understanding emotion perception difficulties has been presented and this has the potential to address underlying issues in emotion perception research.

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APPENDIX 1: QUESTIONNAIRES

1.1 National Adult Reading Test (Nelson & Willison, 1991)

The National Adult Reading Test has been established as a useful estimate of IQ in normal participants and of pre-morbid intellectual functioning in clinical patients. It comprises a set of 50 words, which violate common rules of phoneme production.

Instructions

This is a control task that assesses reading abilities.

Please read aloud the words on the list that will be given to you. You should be warned that there may be many words that you will not recognise, in fact, most people don't know them, so just have a guess at these.

You will have 10 practice words to start with.

Remember you are free to withdraw at any time.

Do you have any questions?

CHORD	SUPERFLUOUS
ACHE	SIMILE
DEPOT	BANAL
AISLE	QUADRUPED
BOUQUET	CELLIST
PSALM	FAÇADE
CAPON	ZEALOT
DENY	DRACHM
NAUSEA	AEON
DEBT	PLACEBO
COURTEOUS	ABSTEMIOUS
RAREFY	DÉTENTE
EQUIVOCAL	IDYLL
NAÏVE	PUERPERAL
CATACOMB	AVER
GAOLED	GAUCHE
THYME	TOPIARY
HEIR	LEVIATHAN
RADIX	BEATIFY
ASSIGNATE	PRELATE
HIATUS	SIDEREAL
SUBTLE	DEMESNE
PROCREATE	SYNCOPE
GIST	LABILE
GOUGE	CAMPANILE

1.2 Fear questionnaire (Wolpe & Lang, 1964)

For the Wolpe and Lang fear schedule, participants had to indicate to what extent (on a five-point scale) they would feel uncomfortable or fearful in particular situations. These situations were very varied in the form and extent of discomfort or fear they were expected to elicit. This test provided an idea of the participants' general experience fear.

Instructions:

This questionnaire describes things and situations which may elicit feelings of fear or discomfort. Please indicate (using the 0 to 4 scale provided) how much these items make you feel fearful or uncomfortable.

	not at all		average		very much so
	0	**1**	**2**	**3**	**4**
01. Noise of a vacuum cleaner	0	1	2	3	4
02. Open wounds	0	1	2	3	4
03. Being alone	0	1	2	3	4
04. Being in a scary place	0	1	2	3	4
05. Loud voices	0	1	2	3	4
06. Corpses	0	1	2	3	4
07. Giving a public speech	0	1	2	3	4
08. Crossing a street	0	1	2	3	4
09. Mentally ill people	0	1	2	3	4
10. Falling	0	1	2	3	4
11. Cars	0	1	2	3	4
12. Being teased	0	1	2	3	4
13. Dentists	0	1	2	3	4
14. Thunder	0	1	2	3	4
15. Sirens	0	1	2	3	4
16. Failure	0	1	2	3	4
17. Entering a room with people in it	0	1	2	3	4
18. Looking down from a tower	0	1	2	3	4
19. Crippled people	0	1	2	3	4
20. Worms	0	1	2	3	4
21. Monsters	0	1	2	3	4
22. Being injected	0	1	2	3	4
23. Bats	0	1	2	3	4
24. Travelling					
By train	0	1	2	3	4
By bus	0	1	2	3	4
By car	0	1	2	3	4
25. Being angry	0	1	2	3	4
26. Figures of authority	0	1	2	3	4
27. Flying insects (flies, wasps, dragonflies)	0	1	2	3	4
28. Seeing another person being injected	0	1	2	3	4

29. Sudden noise	0	1	2	3	4
30. Dull weather	0	1	2	3	4
31. Crowds	0	1	2	3	4
32. Open spaces	0	1	2	3	4
33. Cats	0	1	2	3	4
34. Seeing someone being bullied	0	1	2	3	4
35. Threatening-looking people	0	1	2	3	4
36. Birds	0	1	2	3	4
37. Deep water	0	1	2	3	4
38. Being watched while working	0	1	2	3	4
39. Dead animals	0	1	2	3	4
40. Weapons	0	1	2	3	4
41. Dirt	0	1	2	3	4
42. Crawling insects	0	1	2	3	4
43. Witnessing a fight	0	1	2	3	4
44. Ugly people	0	1	2	3	4
45. Fire	0	1	2	3	4
46. Sick people	0	1	2	3	4
47. Dogs	0	1	2	3	4
48. Being criticised	0	1	2	3	4
49. Spooky shadows	0	1	2	3	4
50. Being in a lift	0	1	2	3	4
51. Witnessing a surgical operation	0	1	2	3	4
52. Angry people	0	1	2	3	4
53. Mice	0	1	2	3	4
54. Blood					
Human	0	1	2	3	4
Animal	0	1	2	3	4
55. Being separated from friends	0	1	2	3	4
56. Narrow rooms and places	0	1	2	3	4
57. Waiting for surgery	0	1	2	3	4
58. Being rejected by others	0	1	2	3	4
59. Planes	0	1	2	3	4
60. Smell of the hospital	0	1	2	3	4
61. Not being valued/appreciated	0	1	2	3	4
62. Harmless snakes	0	1	2	3	4
63. Graveyards	0	1	2	3	4
64. Being ignored	0	1	2	3	4
65. Darkness	0	1	2	3	4
66. Cardiac dysrhythmia	0	1	2	3	4
67. Naked people					
Men	0	1	2	3	4
Women	0	1	2	3	4
68. Lightning	0	1	2	3	4
69. Doctors	0	1	2	3	4
70. Making mistakes	0	1	2	3	4

1.3 Disgust questionnaire (Haidt et al., 1994)

The disgust questionnaire includes a series of 32 questions assessing how sensitive people are to experiencing disgust. This involves a set of true/false questions and questions describing disgusting situations from eight different categories (food, animals, body products, sex, body envelope violations, death, hygiene, and magical thinking) that participants have to indicate the extent to which they would find them disgusting or not. Magical thinking is a domain that cuts across the other seven domains of disgust elicitors via similarity and contagion. Participants filled out their responses on the questionnaires.

Instructions

***Section A:** In this section you are required to respond to the questions by indicating whether the following statements are true or false. Please circle/mark the appropriate response to indicate your choice.*

1. I might be willing to try eating monkey meat, under some circumstances.
   True ☐ False ☐
2. It bothers me to see someone in a restaurant eating messy food with his fingers.
   True ☐ False ☐
3. It would bother me to see a rat run across my path in a park.
   True ☐ False ☐
4. Seeing a cockroach in someone else's house doesn't bother me.
   True ☐ False ☐
5. It bothers me to hear someone clear a throat full of mucus.
   True ☐ False ☐
6. If I see someone vomit, it makes me feel sick.
   True ☐ False ☐
7. I think homosexual activities are immoral.
   True ☐ False ☐
8. I think it is immoral for people to seek sexual pleasure from animals.
   True ☐ False ☐
9. It would bother me to be in a science class, and to see a human hand preserved in a jar.
   True ☐ False ☐
10. It would not upset me at all to watch a person with a glass eye take the eye out of the socket.
    True ☐ False ☐
11. It would bother me tremendously to touch a dead body.
    True ☐ False ☐
12. I would go out of my way to avoid walking through a graveyard.
    True ☐ False ☐
13. I never let any part of my body touch the toilet seat in public restrooms.
    True ☐ False ☐
14. I probably would not go to my favourite restaurant if I found out that the cook had a cold.
    True ☐ False ☐
15. Even if I was hungry, I would not drink a bowl of my favourite soup if it had been stirred by a used but thoroughly washed flyswatter.
    True ☐ False ☐
16. It would bother me to sleep in a nice hotel room if I knew that a man had died of a heart attack in that room the night before.
    True ☐ False ☐

Section B:* *In this section you are required to respond to the items by indicating how disgusting you find them: <u>not</u> disgusting, <u>slightly</u> disgusting, or <u>very</u> disgusting.

1. You see someone put ketchup on vanilla ice cream, and eat it.

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

2. *You are about to drink a glass of milk when you smell that it has gone off.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

3. *You see maggots on a piece of meat in an outdoor rubbish bin.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

4. *You are walking barefoot on concrete, and you step on a worm.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

5. *You see a bowel movement left unflushed in a public toilet.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

6. *While you are walking through a tunnel under a railroad track, you smell urine.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

7. *You hear about an adult woman who has sex with her father.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

8. *You hear about a 30 year-old man who seeks sexual relationships with 80 year-old women.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

9. *You see someone accidentally stick a fishing hook through his finger.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

10. *You see a man with his intestines exposed after an accident.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

11. *Your friend's pet cat dies, and you have to pick up the dead body with you bare hands.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

12. *You accidentally touch the ashes of a person who has been cremated.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

13. *You take a sip of a drink, and then realise that you have drunk from the glass that a friend of yours had been drinking from.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

14. *You discover that a friend of yours changes their underwear only once a week.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

15. *A friend offers you a piece of chocolate shaped like dog poo.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

16. *As part of a sex education class, you are required to inflate a new unlubricated condom using your mouth.*

Not disgusting ☐ Slightly disgusting ☐ Very disgusting ☐

1.4 Beck Depression Inventory (Beck & Steer, 1987)

This questionnaire is a tool for assessing depressed moods.

Instructions

This questionnaire assesses your experiences of sadness. You do not have to complete this information if you are uncomfortable doing so. Please read the following statements and indicate which you most agree with from each section.

1.	0	I do not feel sad.
	1	I feel sad.
	2	I am sad all the time and can't snap out of it.
	3	I am so sad or unhappy that I can't stand it.
2.	0	I am not particularly discouraged about the future.
	1	I feel discouraged about the future.
	2	I feel I have nothing to look forward to.
	3	I feel that the future is hopeless and that things cannot improve.
3.	0	I do not feel like a failure.
	1	I feel I have failed more than the average person.
	2	As I look back on my life, all I can see is a lot of failures.
	3	I feel I am a complete failure as a person.
4.	0	I get as much satisfaction out of things as I used to.
	1	I don't enjoy things the way I used to.
	2	I don't get real satisfaction out of anything anymore.
	3	I am dissatisfied or bored with everything.
5.	0	I don't feel particularly guilty.
	1	I feel guilty a good part of the time.
	2	I feel quite guilty most of the time.
	3	I feel guilty all of the time.
6.	0	I don't feel I am being punished.
	1	I feel I may be punished.
	2	I expect to be punished.
	3	I feel I am being punished.

7. 0 I don't feel disappointed in myself.
1 I am disappointed in myself.
2 I am disgusted with myself.
3 I hate myself.

8. 0 I don't feel I am worse than anybody else.
1 I am critical of myself for my weaknesses or mistakes.
2 I blame myself all the time for my faults.
3 I blame myself for everything bad that happens.

9. 0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

10. 0 I don't cry any more than usual.
1 I cry more now than I used to.
2 I cry all the time now.
3 I used to be able to cry, but now I can't even cry even though I want to.

11. 0 I am no more irritated by things than I ever am.
1 I am slightly more irritated now than usual.
2 I am quite annoyed or irritated a good deal of the time.
3 I feel irritated all the time now.

12. 0 I have not lost interest in other people.
1 I am less interested in other people than I used to be.
2 I have lost most of my interest in other people.
3 I have lost all of my interest in other people.

13. 0 I make decisions about as well as I ever could.
1 I put off making decisions more than I used to.
2 I have greater difficulty in making decisions than before.
3 I can't make decisions at all anymore.

14. 0 I don't feel that I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel that there are permanent changes in my appearance that make me look unattractive.
3 I believe that I look ugly.

15.	0	I can work about as well as before.
	1	It takes an extra effort to get started at doing something.
	2	I have to push myself very hard to do anything.
	3	I can't do any work at all.
16.	0	I can sleep as well as usual.
	1	I don't sleep as well as I used to.
	2	I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
	3	I wake up several hours earlier than I used to and cannot get back to sleep.
17.	0	I don't get tired more than usual.
	1	I get tired more easily than I used to.
	2	I get tired from doing almost anything.
	3	I am too tired to do anything.
18.	0	My appetite is no worse than usual.
	1	My appetite is not as good as it used to be.
	2	My appetite is much worse now.
	3	I have no appetite at all anymore.
19.	0	I haven't lost much weight, if any, lately.
	1	I have lost more than five pounds.
	2	I have lost more than ten pounds.
	3	I have lost more than fifteen pounds.
20	0	I am no more worried about my health than usual.
	1	I am worried about physical problems such as aches or pains, or upset stomach, or constipation.
	2	I am very worried about physical problems & it's hard to think of much else.
	3	I am so worried about my physical problems that I cannot think about anything else.
21.	0	I have not noticed any recent change in my interest in sex.
	1	I am less interested in sex than I used to be.
	2	I am much less interested in sex now.
	3	I have lost interest in sex completely.

1.5 Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983)

This is a tool for assessing levels of anxiety and depression.

Instructions

We would like to thank you for taking part in this project. The next few questions regard how you are feeling and thinking currently, not how you think you **should** feel or think. Your answers are completely confidential. Please indicate which statement comes closest to how you have been feeling in the past 7 days.

1. I feel tense or 'wound-up':

1. Most of the time ☐
2. A lot of the time ☐
3. Time to time, occasionally ☐
4. Not at all ☐

2. I still enjoy the things I used to enjoy:

1. Definitely as much ☐
2. Not quite so much ☐
3. Only a little ☐
4. Hardly at all ☐

3. I get a sort of frightened feeling as if something awful is about to happen:

1. Very definitely and quite badly ☐
2. Yes, but not too badly ☐
3. A little, but it doesn't worry me ☐
4. Not at all ☐

4. I can laugh and see the funny side of things:

1. As much as I always could ☐
2. Not quite so much now ☐
3. Definitely not so much now ☐
4. Not at all ☐

5. Worrying thoughts go through my mind:

1. A great deal of the time ☐
2. A lot of the time ☐
3. From time to time but not too often ☐
4. Only occasionally ☐

6. I feel cheerful:

1. Not at all ☐
2. Not often ☐
3. Sometimes ☐
4. Most of the time ☐

7. I can sit at ease and feel relaxed:

1. Definitely ☐
2. Usually ☐
3. Not often ☐
4. Not at all ☐

8. I feel as if I am slowed down:

1. Nearly all the time ☐
2. Very often ☐
3. Sometimes ☐
4. Not at all ☐

9. I get a sort of frightened feeling like 'butterflies' in the stomach:

1. Not at all ☐
2. Occasionally ☐
3. Quite often ☐
4. Very often ☐

10. I have lost interest in my appearance:

1. Definitely ☐
2. I don't take so much care as I should ☐
3. I may not take quite as much care ☐
4. I take just as much care as ever ☐

11. I feel restless as if I have to be on the move:

1. Very much indeed ☐
2. Quite a lot ☐
3. Not very much ☐
4. Not at all ☐

12. I look forward with enjoyment to things:

1. As much as I ever did ☐
2. Rather less than I used to ☐
3. Definitely less than I used to ☐
4. Hardly at all ☐

13. I get sudden feelings of panic:

1. Very often indeed ☐
2. Quite often ☐
3. Not very often ☐
4. Not at all ☐

14. I can enjoy a good book or radio or TV programme:

1. Often ☐
2. Sometimes ☐
3. Not often ☐
4. Very seldom ☐

1.6 Positive and Negative Affectivity Scale (Watson et al., 1988)

This is a tool for assessing positive and negative affectivity.

Instructions

This test assesses your mood in general.You will see a series of words that describe different feelings and emotions. Please read each item carefully and indicate on the scale of 1-5 to what extent you have felt this way today.

1	**2**	**3**	**4**	**5**
very slightly or not at all	a little	moderately	quite a bit	extremely

Interested	1	2	3	4	5
Distressed	1	2	3	4	5
Excited	1	2	3	4	5
Upset	1	2	3	4	5
Strong	1	2	3	4	5
Guilty	1	2	3	4	5
Scared	1	2	3	4	5
Hostile	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Proud	1	2	3	4	5
Irritable	1	2	3	4	5
Alert	1	2	3	4	5
Ashamed	1	2	3	4	5
Inspired	1	2	3	4	5
Nervous	1	2	3	4	5
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Jittery	1	2	3	4	5
Active	1	2	3	4	5
Afraid	1	2	3	4	5

APPENDIX 2: TASK INSTRUCTIONS

1. Instructions for Face Tasks

This test assesses ability to recognise facial expressions.

You will see a series of pictures of faces. For each face, you must decide whether its expression is most like happiness, sadness, surprise, fear, disgust, or anger. You can make your response by pressing one of the appropriate buttons on the screen, by pressing the appropriate key, or by asking someone to do this for you. The faces are shown for a few seconds each, but you can take as long as you wish to decide on the emotion.

The next face will not be presented until you have made your decision about the previous one.

2. Instructions for the Voice Tasks

This test assesses ability to recognise vocal expressions.

You will hear actors speaking aloud a nonsense phrase/a series of numbers. Their intonation represents an emotion. For each vocal phrase, you are asked to decide which emotion is most closely represented from happiness, sadness, fear, disgust, anger, surprise*. You can make your response by pressing one of the appropriate buttons on the screen, by pressing the appropriate key, or by asking someone to do this for you. You can hear the phrase again if you wish. Try to use your first impressions.

The next vocal phrase will not be presented until you have made your decision about the previous one.

*Surprise was only included as an instruction for the nonsense vocal task.

3. Instructions for Gesture Tasks

This test assesses the ability to recognise 5 basic emotions (happiness, fear, disgust, anger and sadness) represented by body movements.

You will see a series of 50 short video clips between 5 and 9 seconds long. On these slides an actor will display one of the above named emotions.

The actor always starts and finishes in a neutral position with his or her arms by their sides. There are two conditions: in one set of clips, the person will be visible in fully-lit conditions, but you will be unable to see their face. The second set of clips will show a display of reflective strips only. These reflective strips are placed at major points on the person's body – so you will be able to see them moving.

You should decide as quickly as possible which emotion is depicted on the video.

Please press the appropriate button to indicate your choice, or ask the experimenter to do so.

If you are not sure, please take a guess.

APPENDIX 3: AGE CONFUSION TABLES

The pattern of responses by the two age groups are summarised in Tables I-X. All results are given as percentages. Since the emotion hexagon task was designed to manipulate confusion in a particular direction, confusion errors are not reported for that task. T-test analysis was carried out on the errors made in the gestures tasks.

*groups differ significantly (p<0.05), #trend for groups to differ (0.08>p>0.05)

Table I: The pattern of responses for the young group on the dynamic full-light task

		Depicted						
		Anger	Disgust	Fear	Happiness	Sadness	Total label use	False positives
Full-light gestures perceived by the young group	**Anger**	**86.5**	2.4	1.2	13.2*	0.0	103.3	16.8
	Disgust	6.8#	**68.8**	9.1	2.1	2.3	89.1	20.3
	Fear	2.0	9.4	**87.6**	1.2	10.9#	111.1	23.5
	Happiness	3.8	7.9	0.3	**82.3**	0.9	95.2	12.9
	Sadness	0.9	11.5*	1.8	1.2	**85.9**	101.3	15.4
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		13.5	31.2	12.4	17.7	14.1		

Table II: The pattern of responses for the old group on the dynamic full-light task.

		Depicted						
		Anger	Disgust	Fear	Happiness	Sadness	Total label use	False positives
Full-light gestures perceived by the old group	**Anger**	**77.1**	4.1	3.8	24.1*	0.3	109.4	32.3
	Disgust	13.5#	**55.9**	5.9	4.7	5.3	85.3	29.4
	Fear	2.9	10.6	**85.9**	1.5	15.0#	115.9	30.0
	Happiness	4.1	7.9	0.0	**65.6**	0.0	77.6	12.0
	Sadness	2.4	21.5*	4.4	4.1	**79.4**	111.8	32.4
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		22.9	44.1	14.1	34.4	20.6		

Table III: The pattern of responses for the young group on the dynamic point-light task

		Depicted						
		Anger	Disgust	Fear	Happiness	Sadness	Total label use	False positives
Point-light gestures perceived by the young group	**Anger**	**76.8**	3.5	3.2	22.7	1.5	107.7	30.9
	Disgust	6.5*	**58.2**	7.4	5.0	5.6	82.7	24.5
	Fear	1.1	10.0#	**81.2**	0.3	12.4	105.0	23.8
	Happiness	10.6*	7.4	2.9	**71.4**	1.2	93.5	22.1
	Sadness	5.0	20.9*	5.3	0.6	**79.3**	111.1	31.8
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		23.2	41.8	18.8	28.6	20.7		

Table IV: The pattern of responses for the old group on the dynamic point-light task.

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Point-light gestures perceived by the old group	Anger	**72.7**	5.3	2.9	25.6	1.5	108.0	35.3
	Disgust	16.7*	**47.4**	13.5	6.2	6.8	90.6	43.2
	Fear	2.1	15.0#	**72.7**	0.9	16.8	107.5	34.8
	Happiness	3.5*	4.1	2.4	**65.2**	0.8	76.0	10.8
	Sadness	5.0	28.2*	8.5	2.1	**74.1**	117.9	43.8
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		27.3	52.6	27.3	34.8	25.9		

Table V: The pattern of responses for the young group on the nonsense vocal task

		Depicted							
		Anger	Disgust	Fear	Happi-ness	Sadness	Surprise	Total label use	False positives
Nonsense voices perceived by the young group	Anger	**89.7**	3.5	1.5	7.1	0.0	0.0	101.8	12.1
	Disgust	6.2	**64.7**	5.0	7.9	0.3	0.9	85	20.3
	Fear	0.3	3.7	**73.2**	3.8	14.4	4.7	100.1	26.9
	Happiness	2.7	9.4	0.3	**57.7**	0.0	7.4	77.5	19.8
	Sadness	0.3	7.9	16.8	2.9	**85.3**	1.7	114.9	29.6
	Surprise	0.8	10.6	3.2	20.6	0.0	**85.3**	120.5	35.2
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		10.3	35.1	26.8	42.3	14.7	14.7		

Table VI: The pattern of responses for the old group on the nonsense vocal task.

		Depicted							
		Anger	Disgust	Fear	Happi-ness	Sadness	Surprise	Total label use	False positives
Nonsense voices perceived by the old group	Anger	**85.9**	3.2	0.0	12.7	0.0	0.6	102.4	16.5
	Disgust	10.3	**54.7**	5.3	12.4	0.3	3.2	86.2	31.5
	Fear	1.2	7.9	**73.2**	2.4	13.8	7.4	105.9	32.7
	Happiness	1.1	9.1	0.9	**48.5**	0.0	7.9	67.5	19.0
	Sadness	0.3	10.9	16.2	2.9	**85.3**	5.3	120.9	35.6
	Surprise	1.2	14.2	4.4	21.1	0.6	**75.6**	117.1	41.5
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		14.1	45.3	26.8	51.5	14.7	24.4		

Table VII: The pattern of responses for the young group on the verbal vocal task

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Verbal voices perceived by the young group	Anger	**82.9**	9.4	2.1	1.8	1.7	96.2	13.3
	Disgust	7.9	**75.0**	2.1	4.7	12.4	89.7	14.7
	Fear	1.8	3.8	**73.5**	5.0	5.3	84.1	10.6
	Happiness	6.8	7.4	9.1	**84.1**	1.8	107.4	23.3
	Sadness	0.6	4.4	13.2	4.4	**78.8**	22.6	18.2
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		17.1	25.0	26.5	15.9	21.2		

Table VIII: The pattern of responses for the old group on the verbal vocal task.

		Depicted						
		Anger	Disgust	Fear	Happi-ness	Sadness	Total label use	False positives
Verbal voices perceived by the old group	Anger	**74.1**	13.0	4.4	6.8	1.2	99.5	25.4
	Disgust	12.9	**63.8**	2.6	7.0	7.1	93.4	29.6
	Fear	0.9	5.0	**70.9**	5.3	6.7	88.8	17.9
	Happiness	10.3	8.8	11.2	**75.6**	3.2	109.1	33.5
	Sadness	1.8	9.4	10.9	5.3	**81.8**	109.2	27.4
Total depictions		100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		25.9	36.2	29.1	24.4	18.2		

Table IX: The pattern of responses for the young group on the Ekman 60 task

		Depicted							
		Anger	Disgust	Fear	Happi-ness	Sadness	Surprise	Total label use	False positives
Ekman 60 perceived by the young group	Anger	**77.5**	8.9	0.7	0.0	0.4	0.0	87.5	10.0
	Disgust	7.9	**89.6**	6.4	0.0	6.8	0.0	110.7	21.1
	Fear	5.0	0.4	**69.3**	0.0	8.2	8.2	91.1	21.8
	Happiness	0.0	0.0	0.0	**99.6**	0.0	0.7	100.3	0.7
	Sadness	2.8	0.0	1.8	0.0	**83.2**	0.4	88.2	5.0
	Surprise	6.8	1.1	21.8	0.4	1.4	**90.7**	122.2	31.5
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		22.5	10.4	30.7	0.4	16.8	9.3		

Table X: The pattern of responses for the old group on the Ekman 60 task.

		Depicted							
		Anger	**Disgust**	**Fear**	**Happi-ness**	**Sadness**	**Surprise**	**Total label use**	**False positives**
Ekman 60 perceived by the old group	**Anger**	**79.7**	6.7	4.7	0.0	1.2	0.3	92.6	12.9
	Disgust	10.6	**90.6**	5.0	0.0	10.3	0.9	117.4	26.8
	Fear	4.1	1.5	**70.6**	0.3	4.7	9.4	90.6	20.0
	Happiness	0.0	0.0	0.0	**99.4**	0.3	1.5	101.2	1.8
	Sadness	2.9	1.2	1.5	0.0	**80.3**	0.0	85.9	5.6
	Surprise	2.7	0.0	18.2	0.3	3.2	**87.9**	112.3	24.4
Total depictions		100.0	100.0	100.0	100.0	100.0	100.0		
Incorrect labels (misses)		20.3	9.4	29.4	0.6	19.7	12.1		

APPENDIX 4: AGE ANALYSIS WITH SEX OF PARTICIPANT AS A FACTOR

Ekman 60

A significant main effect of emotion was observed [$F_{(3.50,\ 230.34)} = 26.27$, $p<0.001$]. This reflects the differing recognition accuracy levels for the emotions. No other effects reached statistical significance: between age groups [$F_{(1,64)} = 0.07$, $p=0.80$]; emotion x age group interaction [$F_{(3.50,\ 230.34)} = 0.67$, $p=0.60$]; sex of participant [$F_{(1,64)} = 0.99$, $p=0.33$]; emotion x sex interaction [$F_{(3.50,\ 230.34)} = 0.87$, $p=0.48$]; age group x sex interaction [$F_{(1,64)} = 0.21$, $p=0.65$]; emotion x age group x sex interaction (this bordered significance) [$F_{(3.50,\ 230.34)} = 2.46$, $p=0.06$]. It is important to note that ceiling levels in performance cannot explain the lack of differences in the two age groups, except for happiness.

Emotion Hexagon

One female participant in the older group did not complete this task due to time constraints. Analysis revealed a main effect of emotion [$F_{(3.68,\ 231.97)} = 8.53$, $p<0.001$]. There were no other significant effects recorded: between-age group analysis [$F_{(1,63)} = 0.01$, $p=0.94$]; emotion x age group interaction [$F_{(3.68,\ 231.97)} = 1.32$, $p=0.27$]; sex of participant [$F_{(1,63)} = 0.15$, $p=0.70$]; emotion x sex interaction [$F_{(3.68,\ 231.97)} = 0.78$, $p=0.53$]; age group x sex interaction [$F_{(1,63)} = 2.89$, $p=0.09$]; emotion x age group x sex interaction [$F_{(1,63)} = 0.40$, $p=0.79$].

Nonsense vocal emotion test

A significant main effect for emotion was revealed [$F_{(5,320)} = 49.99$, $p<0.001$]. The performance of the older participants was comparable to their younger counterparts [$F_{(1,64)} = 2.90$, $p=0.09$]. A significant emotion x age group interaction was not revealed [$F_{(5,320)} = 0.39$, $p=0.85$].

There was no overall effect of sex on the results [$F_{(1,64)} = 2.93$, $p=0.09$], but there was an emotion x sex interaction [$F_{(5,320)} = 4.64$, $p<0.005$]. The age group x sex interaction did not reach significance [$F_{(1,64)} = 0.29$, $p=0.59$]. The emotion x age group x sex interaction was not significant [$F_{(5,320)} = 1.25$, $p=0.29$]. Multivariate analysis revealed that women were significantly better than men in their recognition of happiness [$F_{(1,64)} = 6.18$, $p<0.05$], and fear [$F_{(1,64)} = 11.46$, $p<0.005$]. By contrast, men attained higher accuracy rates for surprise recognition [$F_{(1,64)} = 4.49$, $p<0.05$]. Men and women did not differ for other emotions [$p>0.22$].

Verbal vocal emotion test

A significant effect of emotion is present [$F_{(4,256)} = 3.93$, $p<0.01$]. There was no main effect of age group, although the younger participants tended to achieve higher accuracy rates [$F_{(1,64)} = 3.09$, $p=0.08$]. A significant age group x emotion interaction was not found [$F_{(4,256)} = 1.04$, $p=0.39$].

The effect of sex was not significant [$F_{(1,64)} = 0.03$, $p=0.89$], nor was there a significant emotion x sex interaction [$F_{(4,256)} = 0.17$, $p=0.95$], or an age group x sex interaction [$F_{(1,64)} = 0.18$, $p=0.67$], or emotion x age group x sex interaction [$F_{(4,256)} = 0.32$, $p=0.85$].

Full-light gestures

There was a significant effect of emotion portrayed on recognition accuracy rates [$F_{(4,256)} = 23.17$, $p<0.001$]. There was also a main effect of age group, with older participants performing less well [$F_{(1,64)} = 18.35$, $p<0.001$]. This was qualified by a significant emotion x age group interaction [$F_{(4,256)} = 2.49$, $p<0.05$]. Multivariate analysis revealed that older participants in comparison with their younger counterparts showed significantly worse recognition of happiness [$F_{(1,64)} = 25.70$, $p<0.001$], disgust [$F_{(1,64)} = 5.16$, $p<0.05$], anger [$F_{(1,64)} = 4.55$, $p<0.05$], but not fear and sadness[$p>0.08$ for them].

Again, there was no effect of sex [$F_{(1,64)} = 0.01$, $p=0.93$], or an emotion x sex interaction [$F_{(4,256)} = 0.48$, $p=0.752$], or an age group x sex interaction [$F_{(1,64)} = 0.22$, $p=0.64$], or an emotion x age group x sex interaction [$F_{(4,256)} = 0.72$, $p=0.58$].

Point-light gestures

A significant main effect of emotion portrayed was observed [$F_{(4,256)} = 23.56$; $p<0.001$]. A significant main effect was recorded between the two age groups, with the younger group performing more accurately [$F_{(1,64)} = 8.65$, $p<0.01$]. There was no significant emotion x age interaction group [$F_{(4,256)} = 1.20$, $p=0.31$].

No effect of sex of participants can be reported [$F_{(1,64)} = 0.84$, p=0.36]. There was no emotion x sex interaction [$F_{(4,256)} = 2.06$, p=0.09], nor an age group x sex interaction [$F_{(1,64)} = 0.94$, p=0.34], or an emotion x age group x sex interaction [$F_{(4,256)} = 1.06$, p=0.37].

APPENDIX 5: LETTER FROM NEUROLOGIST TO PARKINSON'S PATIENTS

See next page for information sheet.

az/el

13 November 2003

DEPARTMENT of CLINICAL NEUROSCIENCES
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Telephone
Fax 0131 332 5150 az@skull.dcn.ed.ac.uk
Email +44 (0)131 537 1168
http://www.dcn.ed.ac.uk

[redacted]

Dear [redacted]

I am writing to you to ask whether you might be willing to take part in a research project, which will be conducted at the Western General Hospital by some colleagues from the Psychology Department in St Andrews University.

My colleagues are investigating the effects of some neurological conditions on how we recognise emotions in other people. The tests involve sitting at a computer for a while, making decisions about images which appear on screen. Most people find the tests quite fun.

I am enclosing an information sheet about the project, so that you can read a little more about this. There is a form on which you can indicate if you are willing to take part and a stamp addressed envelope to send back to Sophia Durrani in St Andrews, who will get in touch with you in due course if you would like to take part in this study.

Best wishes.

Yours sincerely

Dr Richard Davenport
Consultant Neurologist

Parkinson's Information Sheet

Emotion recognition study in Parkinson's disease

You have been invited to take part in a research study. Before you decide to pursue with this, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information and discuss it with others if you wish.

Feel free to contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

Aim The main aim of this study is to explore your emotion recognition abilities.

Testing The testing will take place in one session, but you will be given breaks should you require them. The testing session consists of a few different types of task.

1. First a few background questions about yourself and your emotional experiences will be asked. If you feel uncomfortable answering some of these questions, then you do not have to.

2. In the first main task, you will be shown a series of video clips of people displaying emotions. Your task is to indicate to the experimenter which emotion is being depicted. This task should take a maximum of fifteen minutes.

3. In the next task, you will be asked to read a list of words aloud. This is just a control task.

4. In the next task, you will be shown as series of photographs of faces. We will want you to indicate which emotion is expressed by the face. This task should take a maximum of ten minutes.

5. In the next task, you will hear a series of words being spoken aloud. Your task would be indicate which emotion is expressed by these vocalizations. This task should take ten minutes.

6. In the final set of tasks, you will be asked to respond to a series of questions regarding your experiences of fear, sadness and disgust.

If you wish to complete a few more tasks, then we can arrange this.

Remember that any information you give will remain confidential and you are free to withdraw from the study at any time without giving a reason, and this will not affect your treatment in any way.

The research will take place at the Wellcome Trust Research Clinical Facility, which is part of the Western General Hospital (please see the enclosed map).

Should you decide that you wish to take part, please complete the slip below with your contact details and return it in the stamped-addressed envelope (provided) to Sophia Durrani. We will then try to arrange a suitable date and time for your participation. If you prefer you can call me by 'phone.

Please contact me if you require any further information to help with your decision.

Yours faithfully,

Sophia J. Durrani
Research Assistant
School of Psychology
University of St Andrews
St Andrews
Fife
01334 461992

Please complete if you are interested in participating in this emotion recognition study. Once you have filled this in, could you place it in the stamped-addressed envelope and post to Sophia Durrani. Please use block capitals:

FULL NAME:________________________________

PHONE NUMBER:____________________________

APPENDIX 6: PARKINSON'S PATIENTS' PROFILES

Table I: Background information about Parkinson's participants

Phase	Subject No.	Sex	Age	IQ	Years of education	Hoehn & Yahr score	BDI Score
1	1	F	51	115	10	2	17
	2	M	51	116	12	1	14
	3	F	66	126	16	3	13
	4	F	48	125	15	1	8
	5	M	56	116	19	1	4
	6	F	59	121	18	2.5	11
	7	M	64	108	10	3	10
	8	F	56	118	11	1	7
2	9	F	60	121	17	2	7
	10	F	56	124	26	2	14
	11	M	60	116	14	2	2
	12	M	52	104	10	1	19
	13	F	70	120	11	2	10
	14	M	65	113	10	2	10
	15	M	69	121	13	2.5	10
	16	M	72	119	10	2	6
	17	M	64	103	11	1	5
	18	M	67	114	10	2	10
	19	M	58	102	11	2.5	8
	20	M	64	125	15	2.5	7

Table II: Medication information about Parkinson's participants

Phase	Subject No.	Parkinson's Medication Per Day: Levodopa-derived	Parkinson's Medication Per Day: Dopamine Agonists	Parkinson's Medication Per Day: COMT Inhibitors	Other medication
1	1	250mg Levodopa with carbidopa	6mg Ropinirole		
	2		15mg Ropinirole		
	3	375mg Levodopa with carbidopa	4mg Pergolide	400mg Entacapone	
	4		18mg Ropinirole		2g Sulphasalazine (Arthritis); Warfarin (Heart)
	5				
	6		18mg Ropinirole		100mg Atenolol (Blood pressure)
	7	1000mg Levodopa with carbidopa	12mg Ropinirole		2-5mg Bendrofluazide; 50mg Atenolol; 2mg Coversyl (Blood pressure)
	8		12mg Ropinirole		
2	9				
	10		6mg Cabergoline		
	11		4mg Cabergoline		
	12		1mg Pergolide		0.4-0.8mg Tamsulosin hydrochloride (Prostrate); 50mg Atenolol (Blood pressure); 40mg Simvastatin (Cholesterol)
	13	375mg Levodopa with carbidopa			75 mg Dosulepin hydrochloride (Panic attacks)
	14	250mg Levodopa with carbidopa	21mg Ropinirole		50mg Atenolol (Blood pressure); 40mg Simvastatin (Cholesterol); 200 mg Diltiazem hydrochloride (Heart)
	15	500mg Levodopa with carbidopa			200mg Quinine sulfate (Cramps)
	16		24mg Ropinirole		
	17				0.4-0.8mg Tamsulosin hydrochloride (Prostrate)
	18		2.1mg Pramipexole		Diltiazem hydrochloride; Warfarin (Heart)
	19		12mg Ropinirole		
	20		0.9mg Pramipexole		

APPENDIX 7: PARKINSON'S ANALYSIS WITH SEX OF PARTICIPANT AS A FACTOR

Ekman 60 Face Task

Parkinson's N=15, Control N=31.

There was a significant effect for emotion [$F_{(3.07,\ 128.80)} = 30.73$, $p<0.001$]. There was also an effect of population group [$F_{(1,42)} = 16.22$, $p<0.001$]. This was qualified by a significant emotion x population group interaction [$F_{(3.07,\ 128.80)} = 3.87$, $p<0.05$]. The patients were significantly worse than the control participants in interpreting facial fear [$t(44) = -3.90$, $p<0.001$], and disgust [$t(17.62) = -2.23$, $p<0.05$]. The two groups did not differ for all other emotions all ($p>0.12$).

There was no main effect of sex and all interactions with sex were not significant (all $p>0.58$).

Voice task

Parkinson's N=18, Control N=32.

There was a significant effect of emotion [$F_{(4,184)} = 17.37$, $p<0.001$]. The Parkinson's patients were significantly less accurate on this task than the control group [$F_{(1,46)} = 8.62$, $p<0.01$]. There was no emotion x population group interaction [$F_{(4,184)} = 0.89$, $p=0.47$].

Women were better at this task than men [$F_{(1,46)} = 8.01$, $p<0.01$]. No interactions with sex were significant (all $p>0.10$).

Gesture task

Parkinson's N=20, Control N=31.

The results revealed a significant main effect of emotion [$F_{(4,188)} = 13.43$, $p<0.001$]. This reflects differences in ease of recognition of different emotional gestures. There was no significant difference in performance between the two population groups [$F_{(1,47)} = 0.18$, $p=0.68$]. No significant emotion x population group interaction can be reported [$F_{(4,188)} = 0.71$, $p=0.59$]. This indicates that the two groups are comparable in their performance on this task.

There was no main effect of sex and all interactions with sex were non-significant (all $p>0.26$).